5 Hydrologic Analyses

This chapter summarizes the results of computer simulations of riverflows and reservoir levels that could be expected with the four flow augmentation scenarios. Also included in this chapter are the results of the groundwater modeling and analysis. Results of the hydrologic analysis in the form of graphs, tables, and text were provided to each of the technical disciplines for use in evaluating potential effects on specific natural, cultural, other resources. Thus, the hydrologic analysis is the basis for evaluating all potential effects of the scenarios.

To provide a quantitative analysis of potential streamflow changes in specific reaches and reservoir levels, it is necessary to select specific water sources. The selection of water sources for the Base Case was similar to the historical experience since 1993. The selection of water sources for the 1427i and 1427r scenarios was based on water rights, reservoir refill capability, and other factors that would tend to reduce adverse effects. An entirely different mix of water sources, including storage space in reservoirs not selected for inclusion in this analysis, is possible and entirely likely if a program to secure a large amount of water were implemented. Therefore, the results of the hydrology analysis should be viewed as representative and not definitive.

5.1 Methodology

5.1.1 Surface Water Model

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The hydrology for this analysis is based on computer simulation using MODSIM, a river basin network flow model. With this model, water is allocated consistent with hydrological, physical, and institutional aspects of a river basin. Some of the aspects used in the simulation include:

- Direct flow rights
- Instream flow rights
- Reservoir storage rights
- Reservoir system operations
- Exchanges and operational priorities

MODSIM represents the physical river system as a series of nodes and links. Nodes represent such aspects as reservoirs, demand/diversion structures, inflow locations, and stream gauge locations. Links represent stream reaches, canals, tunnels and other methods of water conveyance.

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5.1.2 Groundwater Model

Modeling of groundwater was not considered necessary for the Base Case, No Augmentation, and 1427i scenarios. Reductions in irrigation water application are considered so small that these scenarios would cause only small differences in the amount and timing of applied irrigation water in relationship to the overall basin water budget. As a result, there would be little change in groundwater recharge and relatively minor variations to aquifer storage and dynamics.

In contrast, the 1427r scenario could result in an average reduction of about 130,000 irrigated acres on the eastern Snake River Plain and that likely would affect groundwater discharge to springs that flow into the Snake River. A groundwater flow model of the eastern SRPA was used to identify the potential effect on groundwater of the 1427r scenario. These effects were then added to the MODSIM model. Also, reallocation of reservoir storage in the Boise and Payette River systems were considered to reduce groundwater discharge to those rivers. Section 5.3 discusses groundwater in the area, the modeling, and potential effects of the 1427r scenario on groundwater.

5.1.3 Period of Analysis and Level of Development

The historical water supply for the 62-year period of 1928-1989 was selected for this analysis. Data for water years later than 1989 is not complete.

The development assumed in the model is that of the early 1990s. This level of development includes the current system of reservoirs, the 1991 irrigation acreage, and the current system of operation for flood control and refill of reservoirs. Also assumed in the model are all of the current physical constraints for storage and release of water and the existing dams. These include maximum storage volumes at reservoirs; maximum release rates for spillways, penstocks, and valves; downstream channel capacities to avoid overbank flows; and minimum reservoir elevations for operation of hydroelectric generators and diversion of water to irrigation canals.

5.1.4 Scenarios and Flow Augmentation Goals

Four scenarios were modeled

- Base Case: Provide 427,000 acre-feet of flow augmentation water each year (existing condition since 1993).

- No Augmentation: Provide no water for flow augmentation (condition prior to 1991).

- 1427i: Provide up to 1,427,000 acre-feet of flow augmentation water to meet deficits in flow targets at Lower Granite Dam. Irrigation shortages would be minimized by using large drawdowns of Reclamation reservoirs.

- 1427r: Provide up to 1,427,000 acre-feet of flow augmentation water to meet deficits in flow targets at Lower Granite Dam. Reservoir elevations would be maintained at or near the Base Case levels with shortages assumed by irrigation.

The flow augmentation goal of each modeled scenario is to annually provide a volume of water to Lower Granite Lake each year (modeled as inflow to Brownlee Reservoir for this study). This volume of water is in addition to the “incidental” flow which is mostly spill in spring months from flood control operation and freshet local runoff below reservoirs. Incidental flow in the later summer and fall months is comprised mostly of stream gains in the lower basin, irrigation return flows, and some operational spill from major subbasins.

The goal of the Base Case (427,000 acre-feet flow augmentation) is to provide 427,000 acre-feet of water each year in a pattern that provides 75,000 acre-feet in June, 138,600 acre-feet in July, 140,400 acre-feet in August, and 72,000 acre-feet in September. The No Augmentation scenario would provide no water for flow augmentation. The goal of the 1427i and the 1427r scenarios is to provide a sufficient volume of water to meet monthly target deficits at Lower Granite Dam, but only up to a total of 1,427,000 acre-feet. Target flows at Lower Granite Dam under the 1995 BIOP are:

April 10-June 20	June 21-August 31

85,000-100,000 cfs	50,000-55,000 cfs

Reclamation modeled deficits in meeting target flows at Lower Granite Dam; the current operation of Dworshak Dam for flow augmentation was assumed. These monthly deficits, then became the flow augmentation goal for each month of modeling.

Figure 5-1 shows the probability of meeting the seasonal target volume (obtained by multiplying the seasonal average flow for the period of the flow augmentation season) under the current 1995 BIOP operation. This operation includes the Base Case target volume of 427,000 acre-feet delivered from the Snake River upstream of Brownlee Dam. The figure shows that seasonal deficit under the Base Case would range from over 8 MAF to about 250,000 acre-feet. Adding 1MAF would eliminate the deficit about 40 percent but there would still be a deficit about 60 percent of the time (follows the 1 MAF line to the intersection of the exceedance curve and then down to the percent probability of a deficit, 60 percent). Delivering an additional 1 MAF, a total of 1,427,000 acre-feet, is the goal of the 1427i and 1427r scenarios.

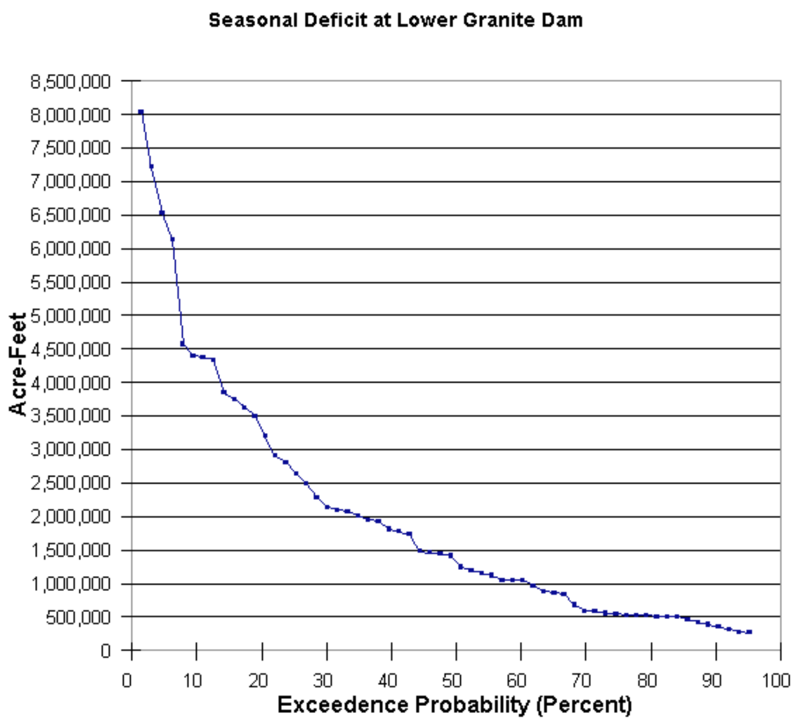

Figure 5-1 Probability of a Seasonal Deficit At Lower Granite Dam With the 1995 BIOP Flows which includes a target flow of 427,000 acre-feet from the Snake River upstream of Brownlee Reservoir

The 1995 BIOP provides that the flow targets are to be considered to be "seasonal averages." However, in the TMT and Implementation Team processes, the fish managers have expressed serious concerns whenever flow targets have not been met at any time, whether or not seasonal average flows exceeded flow targets. The "seasonal averages" of the BIOP recognize that it is highly unlikely that flow targets could be met every single day of the flow augmentation season. Even in the best water year, meeting a daily requirement is to be impossible. For example, the year 1997 was the best water year on record for many parts of the Northwest. The established target flows for 1997, based on the criteria established in the 1995 BIOP, were: April 10 - June 20 (100,000 cfs) and June 21 through August 31 (55,000 cfs). Although actual flows exceeded target flows by a considerable amount during most days of the migration period and the average far exceed the target, target flows were not achieved ever day. Flows past Lower Granite Dam during the 1997 Flow augmentation season are illustrated in attachment B.

5.1.5 Water Sources for Base Case

Base Case water supply has historically been obtained through the reassignment of some storage space, purchase of storage from spaceholders, annual purchases from the rental pools, purchase of natural flow rights, and use of powerhead space when other sources were insufficient. Sources used for the Base Case hydrology analysis are generally the same as those actually used and currently available. Sources used in the Base Case are shown in table 5-1.

Table 5-1 Water Sources for Base Case Hydrology (Acre-Feet)

Item	Palisades	American Falls	Walcott	Jackson	Total
Snake River Upstream of Milner Dam					
Powerhead space	157,000		115,000		272,000
Rentals	237,000				237,000
Acquired space	10,022	8,951		3,923	22,896
Total Upstream of Milner Dam[1]					531,896
Boise and Payette River Basins					
Item	Cascade	Deadwood	Lucky Peak	Anderson Ranch	Total
Powerhead space				41,000	4,100
Rentals	60,000				60,000
Uncontracted space	69,600	25,400	3,554		135,900
Acquired space			37,378		
Total Boise/Payette					236,900

[1]Includes 237,000 acre-feet of actual water, the remainder is space which may not fill each year

5.1.6 Selection of Water Sources and Assumptions for 1427r and 1427i

In identifying potential water sources for an additional 1MAF for flow augmentation, it was decided that a combination of sources–Reclamation storage and natural flow rights–should be used for the hydrology simulation. This spreads the burden over several areas including Reclamation project lands and privately irrigated lands rather than concentrating the burden in a smaller area. Privately irrigated non-prime farmlands in Wyoming, Nevada, Oregon, and Idaho along with the acreage of highlift pumpers along the Snake River in Idaho were identified. Acquisition of the natural flow rights for these irrigated lands would of necessity remove the lands from the irrigated land base. However, use of the land could vary and might include a switch from irrigated agriculture to dryland agriculture.

5.1.6.1 Natural Flow Rights

Little information was available on diversions for the selected lands with natural flow rights, so assumptions were made on cropping patterns and diversions. Farmlands, except those supplied by highlift pumping, were assumed to be planted in grass pasture and received a full water supply every year with an application efficiency of 50 percent. Lands supplied by highlift pumping are assumed to be planted in potatoes and to have an irrigation efficiency of 85 percent. Consumptive crop requirements were calculated with a Blaney-Criddle program using precipitation and temperature data applicable to each area and crop.

Calculation of return flows was necessary, since taking the lands out of production would alter streamflows not only during the irrigation season but also between irrigation seasons. Return flows from privately irrigated lands were estimated based on precipitation and temperature data for each area, a 50 percent irrigation efficiency from flood irrigation (50 percent of the water applied returns to the river), and half of the return flow is via the surface and half is by subsurface flow. Surface return flows were assumed to reenter the system in the proportion of 4/7 during the month of application, 2/7 the following month, and 1/7 the third month. Subsurface return flows were assumed to reenter the system proportionately over a period of a year. It was further assumed that there would be no return flows from lands irrigated by highlift pumps.

Natural flow rights from a total of 221,500 acres of land were identified as summarized in table 5-2.

Table 5-2 Lands and Natural Flow Rights Assumed for the 1427i and 1427r Scenarios

State	River Basin	Acres	Water Supply (Acre-Feet)
Wyoming	Snake	30,000	27,640
Nevada	Owyhee	15,000	21,900
Idaho	Salmon	71,500	87,470
Oregon	Grande Ronde	37,000	21,680
Idaho highlift pumping	Snake	68,000	134,950
Total		221,500	293,640

A total water supply of 311,290 acre-feet from natural flow rights was used with the 1427i and the 1427r scenarios. This includes the total from table 5-2 plus 17,650 acre-feet of natural flow rights purchased under Reclamation's current flow augmentation program. This latter natural flow right was associated with 4,420 acres of farmland in Oregon.

After water use values were computed and simulation runs had been made, Reclamation discovered that the lands irrigated by highlift pumping were usually planted in a crop rotation pattern that included the primary crops of potatoes along with beans, mint, onions, alfalfa, and wheat. A sensitivity analysis was done to determine how this might affect water use compared with a crop consisting of potatoes only. We assumed that 50 percent of the land at any one time would be planted in potatoes and the other 50 percent would be planted in equal amounts of beans, onions, wheat, and alfalfa. This sensitivity analysis assumed the worst case, a dry year (1977), when only 4 inches of rain fell. The results indicated that the combination of crops in a dry year use about 20.48 inches of water compared to 24.82 inches average annual use of a crop consisting of potatoes only. The total amount of water pumped during this worst case is about 25,900 acre-feet less than the value used in the study. Since the difference would be less in average and wet water years, Reclamation determined the difference in water use would not have a significant effect on the overall results of this flow augmentation analysis.

5.1.6.2 Reclamation Storage

Selection of storage space in Reclamation reservoirs was based on meeting the flow augmentation goal with the least adverse effect on irrigation (1427i) or reservoir resources (1427r). Factors considered were the amount of total storage space compared to the acres of land served, contracted space in more than one reservoir by a contracting entity, whether Reclamation storage was used as the full supply or supplemental supply to lands, and reservoir refill capability. The size of the block of water was another consideration in the simulation. Large blocks of water were identified for reallocation to simplify modeling. Reclamation storage was selected from reservoirs in three areas–upstream of Milner Dam, the Boise and Payette River basins, and the Owyhee River basin.

5.1.6.2.1 1427i Scenario

Table 5-3 summarizes the storage space selected from reservoirs upstream of Milner Dam.

Table 5-3 Reservoir Sources Selected for the 1427i Scenario Upstream of Milner Dam (Acre-Feet)

Item	Palisades	American Falls	Walcott	Jackson	Ririe	Total
Base Case Sources						
Inactive space	157,000		115,000			272,000
Acquired space	10,022	8,951		3,923		22,896
Additional Storage for 1427i Scenario						
Contracted acquired	324,000	300,000		117,191	80,000	821,191
Total upstream of Milner Dam	491,022	308,951	115,000	121,114	80,000	1,116,087

Table 5-4 summarizes water sources selected in the Boise/Payette River basins for the 1427i scenario.

Table 5-4 Reservoir Sources Selected for the 1427i Scenario in the Boise/Payette River Basins (Acre-Feet)						
Item	Cascade	Deadwood	Lucky Peak	Arrowrock	Anderson Ranch	Total
Base Case Sources						
Inactive					41,000	41,000
Reassigned uncontracted	69,600	25,400	3,554			98,554
Acquired contracted			37,378			37,378
Additional Storage for 1427i						
Uncontracted reassigned	100,000	40,000	50,000			190,000
Contracted acquired	100,000		35,000		100,000	235,000
Total in Boise/Payette River basins	269,000	65,400	125,932		141,000	601,932

The water sources for the 1427i scenario also includes acquiring 200,000 acre-feet of active storage space in Lake Owyhee.

5.1.6.2.2 1427r Scenario

Table 5-5 summarizes water sources upstream of Milner Dam for the 1427r scenario.

Table 5-5 Reservoir Sources Selected for the 1427r Scenario Upstream of Milner Dam (Acre-Feet)						
Item	Palisades	American Falls	Walcott	Jackson	Ririe	Total
Base Case Sources						
Inactive storage	157,000		115,000			272,000
Acquired space	10,022	8,951		3,923		22,896
Additional Storage for 1427r						
Contracted acquired	424,033	800,000	97,000	417,191	80,000	1,818,224
Total upstream of Milner Dam	591,055	808,951	212,000	421,114	80,000	2,113,029

Table 5-6 summarizes water sources selected in the Boise and Payette River for the 1427r scenario.

Table 5-6 Reservoir Sources Selected for the 1427r Scenario in the Boise and Payette River Basins (Acre-Feet)						
Item	Cascade	Deadwood	Lucky Peak	Arrowrock	Anderson Ranch	Total
Base Case Sources						
Inactive space					41,000	41,000
Reassigned space	69,600	25,400	3,554			98,554
Acquired space			37,378			37,378
Additional Storage for 1427r						
Uncontracted reassigned	100,000	40,000	50,000			190,000
Contracted acquired	250,000		35,000	150,000	359,000	794,000
Total Boise/Payette River basins	419,600	65,400	125,932	150,000	400,000	1,160,932

The water sources for the 1427r scenario also includes 200,000 acre-feet of active storage space in Lake Owyhee.

5.1.6.3 Operation Requirements and Considerations

There are numerous formal and informal agreements on operation of the dams in the system. These range from reservoir elevations and riverflow restrictions related to flood control rules to informal rules of thumb that are met only when water supply and other conditions are favorable. Attachment C summarizes operating considerations and identifies those modeled for this analysis.

In general, flood control rules and more formal agreements on minimum target flows were modeled while less formal operational considerations that focus on improved fishery and water quality were not modeled. Although not modeled, some operating considerations would always be met. Section 5.2.4 provides information on how often selected operation considerations would be met.

5.1.6.4 Other Factors

Decreases in diversions and resulting decreases in return flows were computed for each of the natural flow water rights areas analyzed. These incremental gains and losses were used as input to MODSIM to analyze impacts on river and reservoir operations along with flow augmentation accomplishments.

After data sets were developed, surface water model runs were completed and results were summarized in terms of flows, irrigation diversions and shortages, reservoir levels, and storage accounts.

Power generation capability was quantified for each scenario using MODSIM output of flows and reservoir content.

5.1.7 Summary of Modeling

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5.1.7.1 No Augmentation Scenario

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Modeling for the No Augmentation scenario is based on the following:

- IDWR planning model data set of gains and diversions; physical representation of reaches, diversion, and return flow lags for the 1928-1989 period of record and early 1990s diversions and gain patterns.

- IDWR natural flow rights; rights of less than 4 cfs were consolidated.

- Reclamation storage contracts and other Reclamation data on constraints to reservoir and river operations.

5.1.7.2 Base Case

The Base Case adds to the No Augmentation scenario by assigning specific water sources (see table 5-1) to result in delivery of 427,000 acre-feet of inflow to Brownlee greater than incidental flow. Incidental flow is essentially the flow that isn't regulated. However, incidental flow under the Base Case decreases somewhat because flow augmentation results in less carryover in reservoirs, more reservoir space, and decreased spill during flood control.

5.1.7.3 1427i

The 1427i scenario adds to the No Augmentation scenario by assigning specific water sources (see tables 5-2, 5-3, and 5-4) to meet a demand of up to 1,427,000 acre-feet of flow augmentation water. The demand is defined as the deficit in meeting target flows at Lower Granite Dam under the current BIOP operation of the lower Snake River. An additional consideration is that reservoirs would be drafted to meet all demands.

5.1.7.4 1427r

The 1427r scenario adds to the No Augmentation scenario by assigning specific water sources (see tables 5-2, 5-5, and 5-6) to meet a demand of up to 1,427,000 acre-feet of flow augmentation water. Demand for flow augmentation is the same as for 1427i. However, the second consideration is that reservoir levels are to be maintained at levels similar to the Base Case in order to minimize adverse effects to reservoir water quality, recreation, and fish and wildlife.

The 1427r scenario requires nearly half of the active space in Reclamation reservoirs and would induce considerable irrigation shortage. This amount of shortage, or reduced application of water to irrigate crops, would have a significant effect on groundwater levels. As a result, potential effects on the eastern SRPA were modeled and incorporated into model results.

5.2 Model Findings

5.2.1 Flow Augmentation

The goal of the Base Case is to provide 427,000 acre-feet every year. The goal of the 1427i and 1427r scenarios is to provide up to 1,427,000 acre-feet to help meet the deficit in target flows at Lower Granite Dam. These deficits are less than 1,427,000 acre-feet in 22 of 62 years but range up to 8,242,005 acre-feet in the remaining 40 years.

Average monthly inflow to Brownlee Reservoir under the four scenarios is shown in figure 5-2.

5.2.1.1 Base Case Accomplishment

The hydrology simulation results in tables of monthly values of flows provided by flow augmentation and the total for the year. Annual totals provided by flow augmentation were compared with the annual goal of 427,000 acre-feet. The hydrologic model, using current water sources for flow augmentation, indicates that Reclamation can provide the target augmentation flow of 427,000 acre-feet in about 82 percent of the years (see table 5-7). In 92 percent of the years, 300,000 acre-feet can be provided and in 95 percent of the years 250,000 acre-feet can be provided. The minimum amount delivered in the driest year would be 179,000 acre-feet.

Table 5-7 Future Delivery of Augmentation Flows Under the Base Case Scenario (Based on the 62-year Period of Analysis (1928-1989)

Level of Flow Augmentation	Percentage of Time Met	Number of Years Met
427,000 acre-feet	82	51
300,000 acre-feet	92	57
250,000 acre-feet	95	59

Reclamation has determined that additional permanent acquisitions of storage space or natural flow rights would be needed to increase the reliability of providing the target flow of 427,000 acre-feet.

5.2.1.2 1427i Accomplishment

The annual flow augmentation totals provided by the 1427i scenario were compared with the seasonal deficit in meeting flow augmentation targets at Lower Granite Dam under the Base Case. The goal was considered met in any year that the seasonal total provided by the scenario was (1) greater than the deficit amount or (2) was 1,427,000 acre-feet. Deficits would be less than 1,427,000 in 22 of 62 years and the 1427i scenario would provide the deficit amount in each of those years. Deficits would be greater than 1,427,000 acre-feet in 40 of 62 years. The 1427i scenario would provide 1,427,000 acre-feet in 38 of 40 years and would provide 1.1 and 1.2 MAF in the remaining 2 years. In summary, the 1427i scenario meets the flow augmentation goal in 60 of 62 years (97 percent of the years).

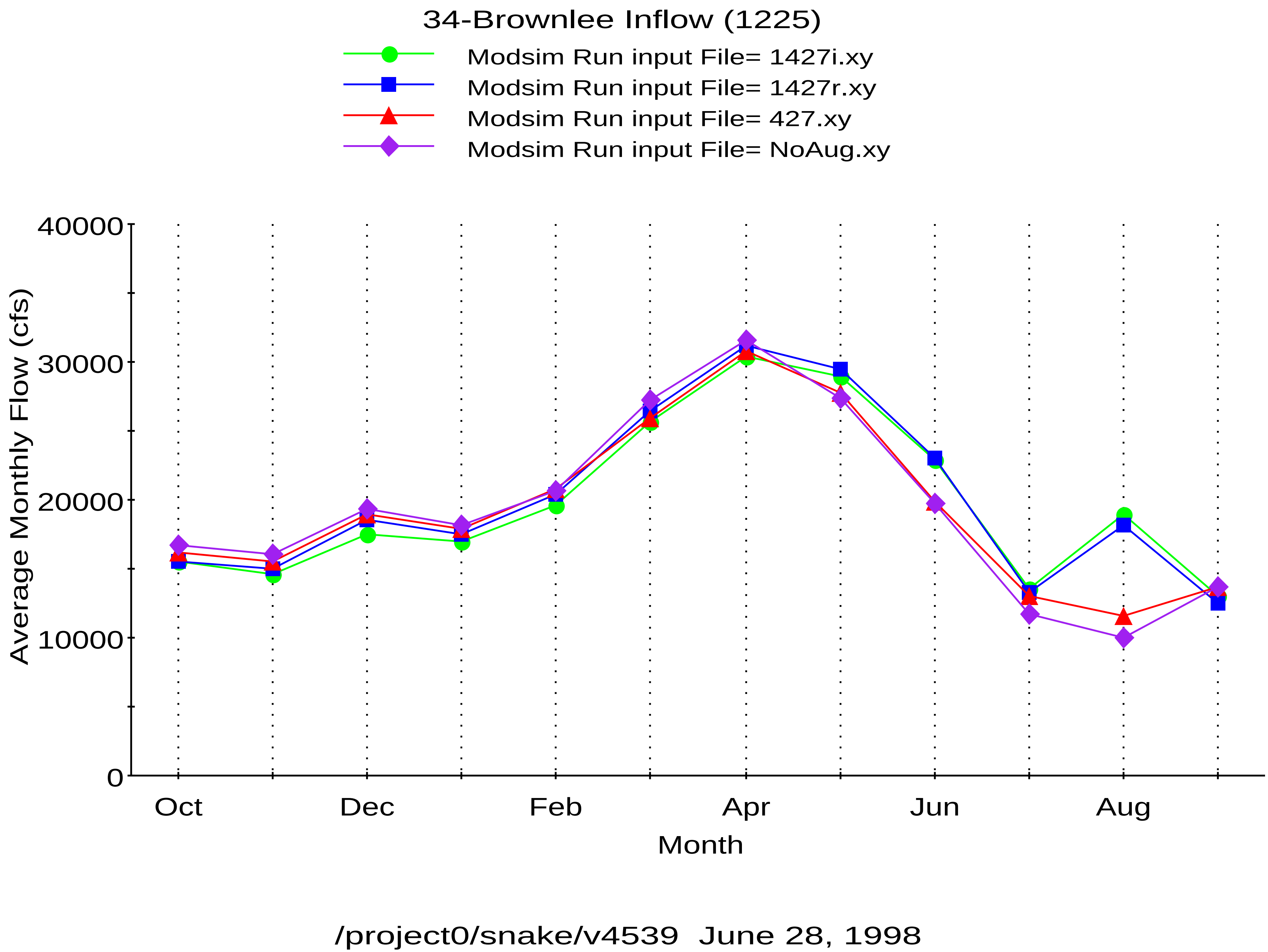

Figure 5-2 Average Monthly Inflow to Brownlee Reservoir

5.2.1.3 1427r Accomplishment

The annual flow augmentation totals provided by the 1427r scenario were compared with the seasonal deficit in meeting flow augmentation targets at Lower Granite Dam under the Base Case. As indicated in the previous section, the goal was considered met in any year that the seasonal total provided by the scenario was (1) greater than the deficit amount or (2) was 1,427,000 acre-feet. Deficits would be less than 1,427,000 in 22 of 62 years and would be greater than 1,427,000 acre-feet in 40 of 62 years. The 1427r scenario would provide the deficit amount in all years when the seasonal total was less than 1,427,000 acre-feet and would provide 1,427,000 acre-feet in all other years. In summary, the 1427i scenario meets the flow augmentation goal in 62 of 62 years (100 percent of the years).

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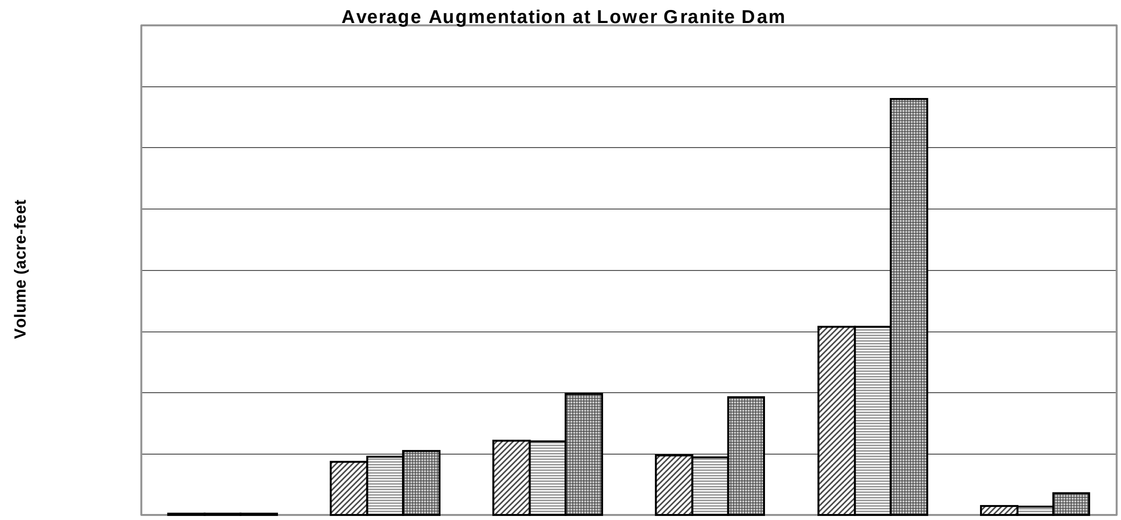
5.2.1.4 Relationships to Lower Granite Dam Target Flows

As indicated earlier and shown in figure 5-1, flow augmentation deficits are greater than 1,427,000 acre-feet during 60 percent of the period of record (1928-1989). As a result, implementation of the 1427i or 1427r scenario would fail to meet the deficit demand at Lower Granite Dam in at least 60 percent of the years. This failure to meet deficit demand is more striking when defined by months. Table 5-8 shows the demand by month at Lower Granite Dam and the number of months the target would be met under each scenario.

Table 5-8 Flows Targets at Lower Granite Dam During Augmentation Period and Accomplishment of the 1427i and 1427r Scenarios (Assumes Current Dworshak Operation and is Based on 62 Years of Historical Records, 1928 Through 1989)

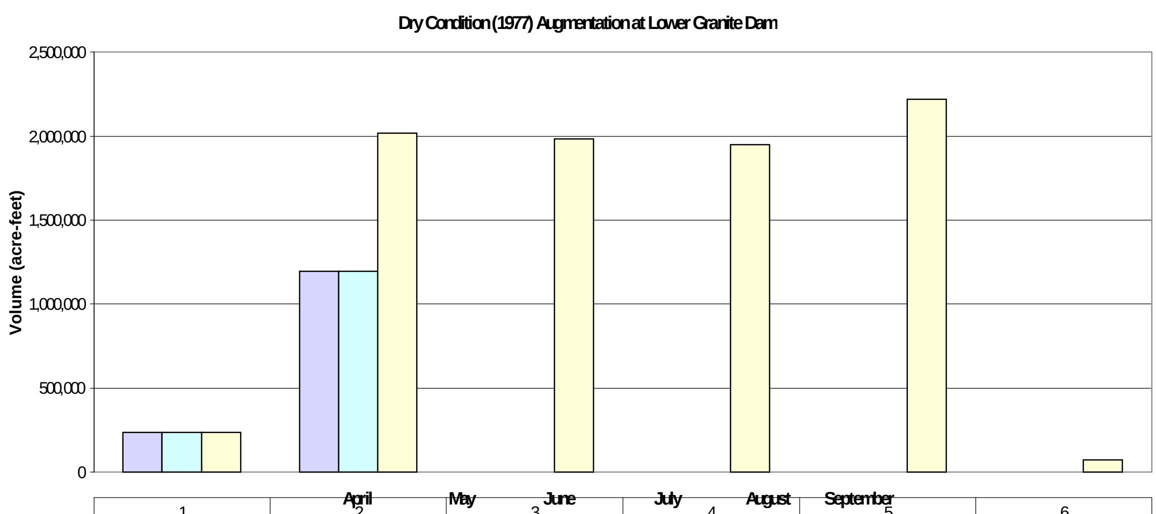
Period	April 10-30	May 1-31	June 1-31	July 1-31	August 1-31
Target flow	85,000 to 100,00 cfs	85,000 to 100,00 cfs	50,000 to 100,00 cfs	50,000 to 55,000 cfs	50,000 to 55,000 cfs
Scenarios	Number of Months Target Is Met out of 62 Months and (Percent of Months)				
1427i	62 (100)	59 (95)	53 (85)	48 (77)	25 (40)
1427r	62 (100)	60 (97)	54 (87)	50 (81)	26 (42)

Figures 5-3, 5-4, and 5-5 present information on demand and water provided in graphical form for the average water year, a dry year (1977,) and a wet year (1983). The month of September is included in the graphs because delivery requests for 427,000 acre-feet under the Base Case includes delivery of a portion of the water during September. It was assumed in the hydrologic studies that this request would continue into the future even though September is not within the 1995 BIOP target flow period.



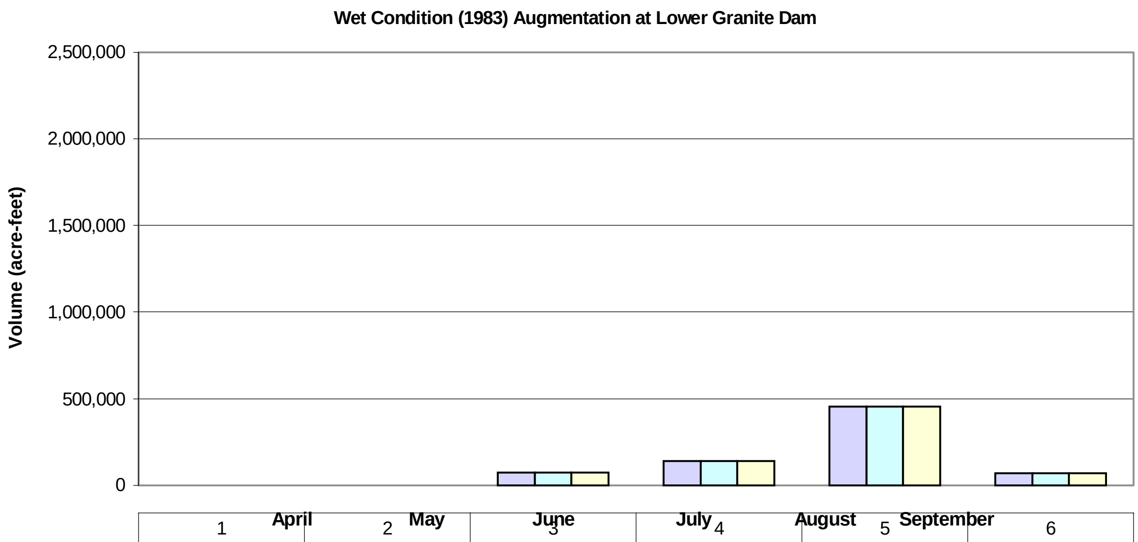
	1	2	3	4	5	6
1427i Supply	3,933	174,494	242,254	194,252	615,165	29,083
1427r Supply	3,933	191,238	241,080	189,702	614,853	26,662
Demand	3,933	210,925	396,544	385,203	1,359,402	72,000
	April	May	June	July	August	September

Figure 5-3 Average Target Flow Demand and Water Supply Provided by the 1427I and 1427r Scenarios for the 1928-1989 Period



	1	2	3	4	5	6
1427i Supply	234,483	1,192,517	0	0	0	0
1427r Supply	234,483	1,192,517	0	0	0	0
Demand	234,483	2,017,943	1,981,139	1,948,466	2,217,951	72,000

Figure 5-4 Target Flow Demand and Water Supply Provided by the 1427I and 1427r Scenarios in a Dry Year (1977)



	1 April	2 May	3 June	4 July	5 August	6 September
1427i Supply	0	0	75,000	139,800	453,492	72,000
1427r Supply	0	0	75,000	139,800	453,492	72,000
Demand	0	0	75,000	139,800	453,492	72,000

Figure 5-5 Target Flow Demand and the Water Supply Provided by the 1427I and 1427r Scenarios in a Wet Year (1983)

5.2.2 Irrigation Shortages

Irrigation demand and water available for diversion for Reclamation projects that would be affected by flow augmentation were identified. Based on these data, tables of irrigation shortages for an average, a dry year, and a wet year were developed. Table 5-9 summarizes the data.

Table 5-9 Irrigation Shortages for All Scenarios (Acre-Feet)

Hydrologic Condition	Base Case	No Augmentation	1427i	1427r
Average	72,216	72,964	187,743	770,746
Dry year (1977)	335,634	444,607	1,043,335	2,201,459
Wet year (l983)	2,261	2,261	3,593	132,633

5.2.3 River Flows and Reservoir Elevations

Exceedance curves, end of month reservoir contents, and average monthly flows for all modeled reservoirs and river reaches for each flow augmentation scenario were prepared and provided to technical personnel to use in evaluating the effects of the scenarios. This material is summarized in figures 5-6 to 5-23 which show average end of month contents and average monthly releases and end of season content (end of September) for the 62-year period of analysis for the following facilities:

- Jackson Lake

- American Falls Reservoir
- Milner Dam
- Anderson Ranch Reservoir
- Lucky Peak Lake
- Cascade Reservoir
- Deadwood Reservoir
- Lake Owyhee

In general, only the active portions of the reservoir content are modeled and included in the figures. However, exceptions are Palisades, Walcott, and Anderson Ranch Reservoirs which include active and inactive space. Inactive space in these reservoirs is used for powerhead which is used as a source of water for flow augmentation in this analysis.

Graphs of reservoir content and outflow for wet (1983) and dry (1977) water supply conditions are included in attachment D.

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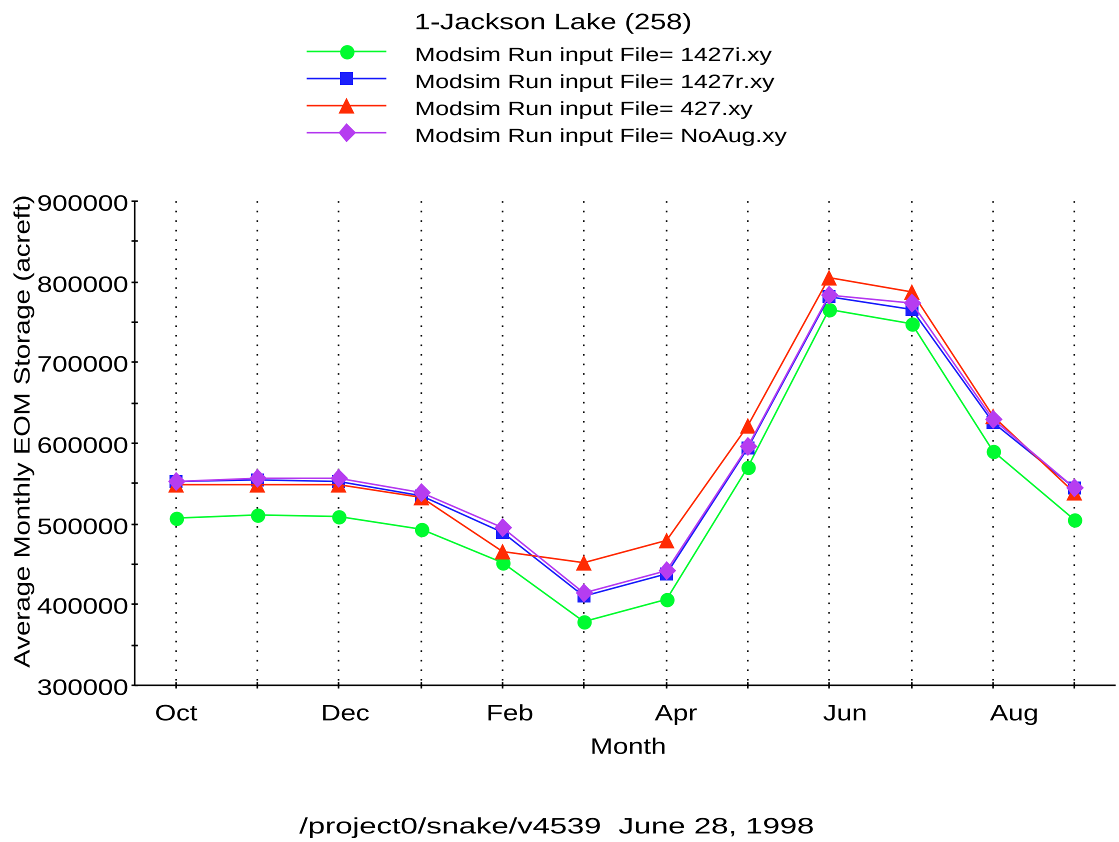
5.2.4 Operational Requirements and Considerations

This section provides information on how often selected operating considerations are met under each of the scenarios. These operating considerations are met only within operational flexibility while meeting irrigation demands and flow augmentation targets. A complete list of operating considerations and the reason for the consideration is included in attachment C.

5.2.4.1 Snake River Upstream of Milner Dam

Table 5-10 Percent of Time Selected Operating Considerations Are Met Upstream of Milner Dam

Reservoir and Consideration	Base Case	No Augmentation	1427i	1427r
Jackson Lake release				
280 cfs minimum (all months)	100	100	100	100
600 cfs maximum (October-March)	75	70	71	70
Palisades Reservoir release				
550 cfs minimum (October-March)	100	100	100	100
Island Park release				
2,000 cfs maximum (normal) (all months)	100	100	100	100
3,260 cfs maximum (flood control) (all months)	100	100	100	100
100 cfs minimum (October-March)	85	85	85	85
12,000 cfs maximum at Rexburg (all months)	100	100	100	100
American Falls				
100,000 acre-foot minimum (September)	58	66	34	56
4345 feet elevation maximum (November- March)	58	54	53	53
American Falls releases				
300 cfs minimum at Neeley (November-March)	85	87	82	88
20,000 cfs maximum at Minidoka (all months)	98	98	98	100
Lake Walcott (Minidoka Dam)				
4240 feet elevation minimum (November-February)	100	100	100	100
Milner Dam release–200 cfs minimum	84	80	82	85



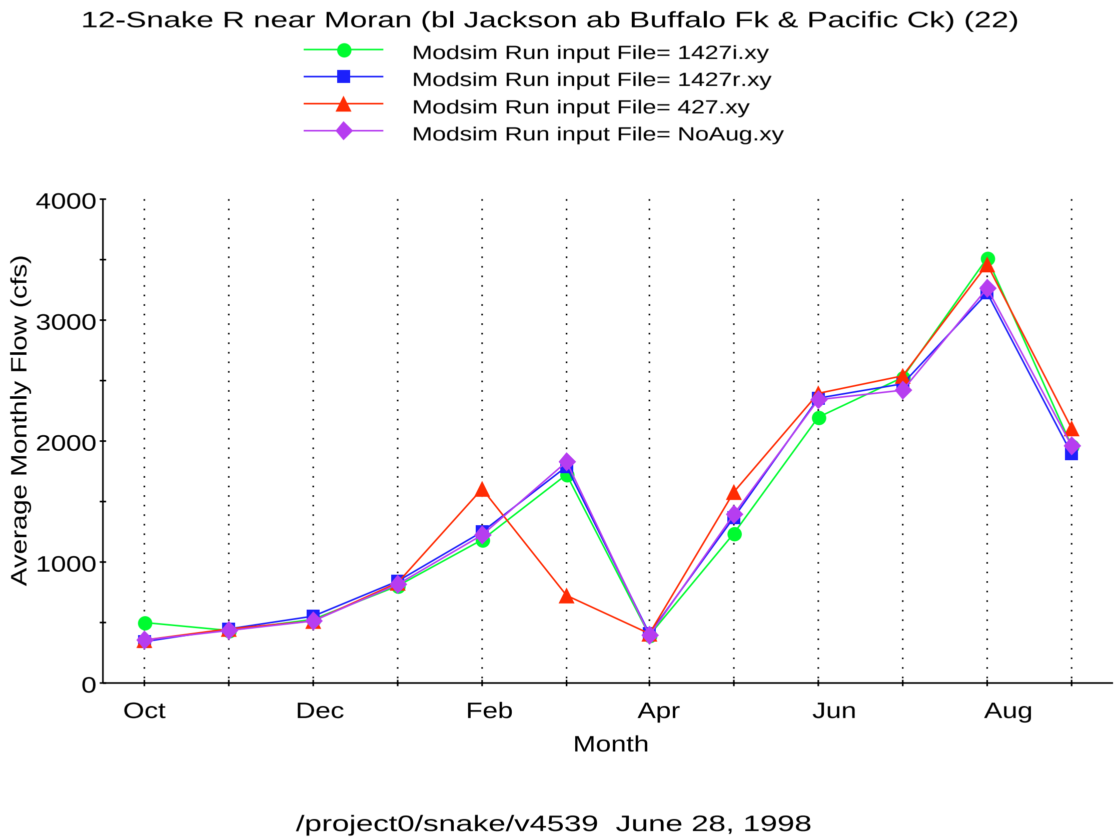


Figure 5-6 Jackson Lake Average end of Month Content and Average Monthly Release (Snake River Flow Near Moran)

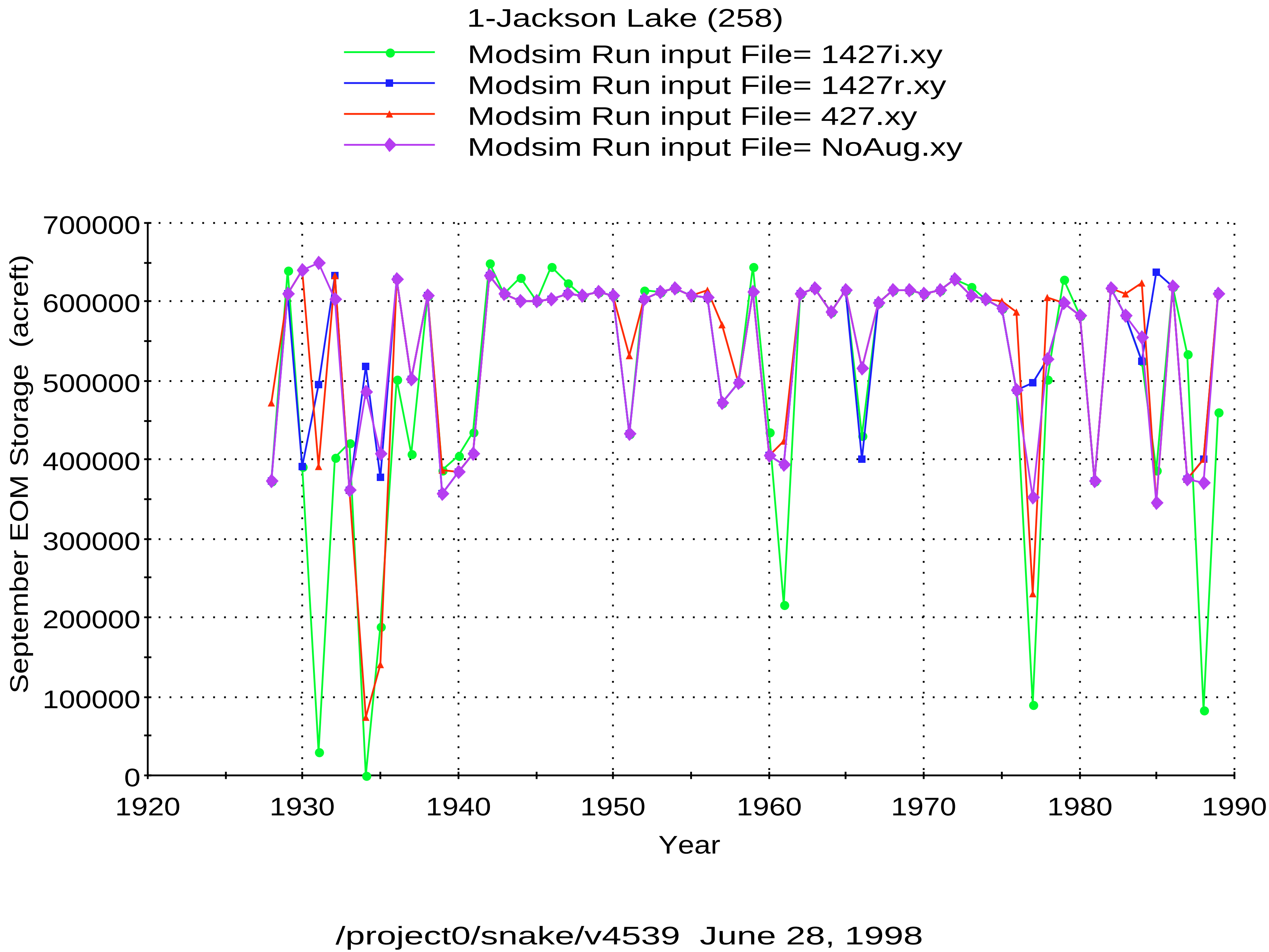
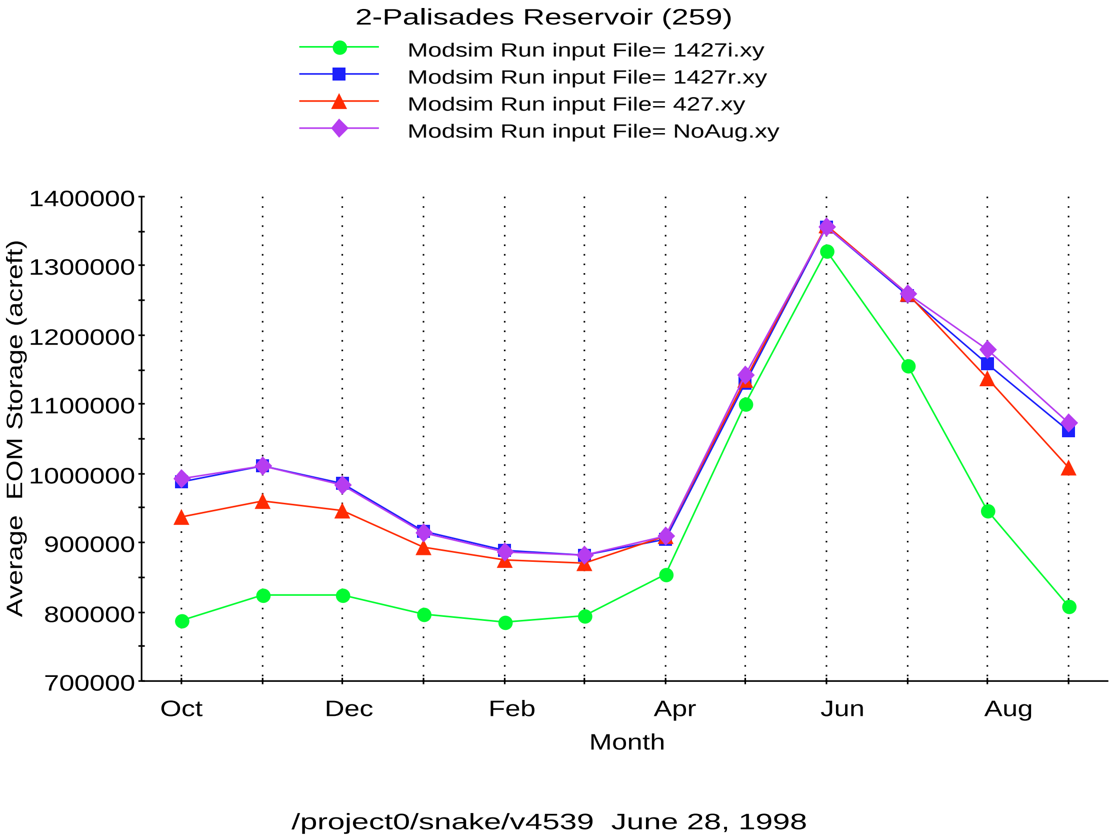


Figure 5-7 Jackson Lake End of Season Content (1928-1989)



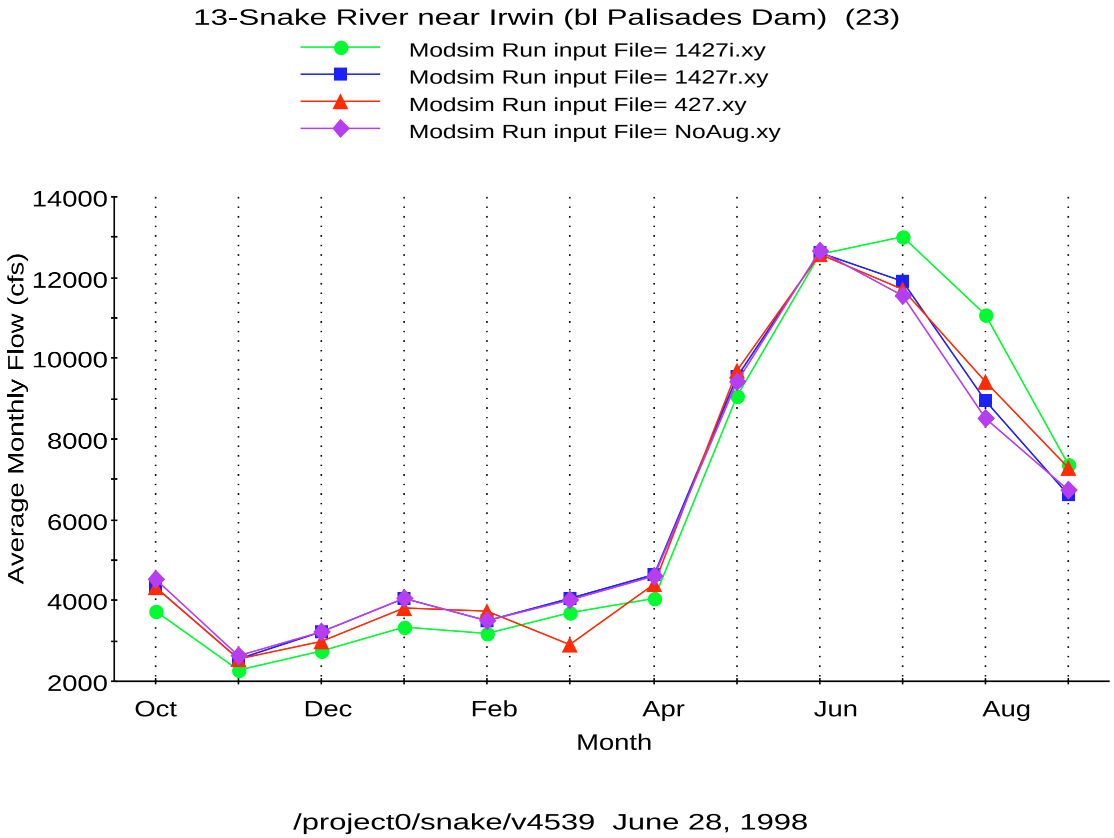


Figure 5-8 Palisades Reservoir Average End of Month Content and Average Monthly Release (Snake River Flow New Irwin)

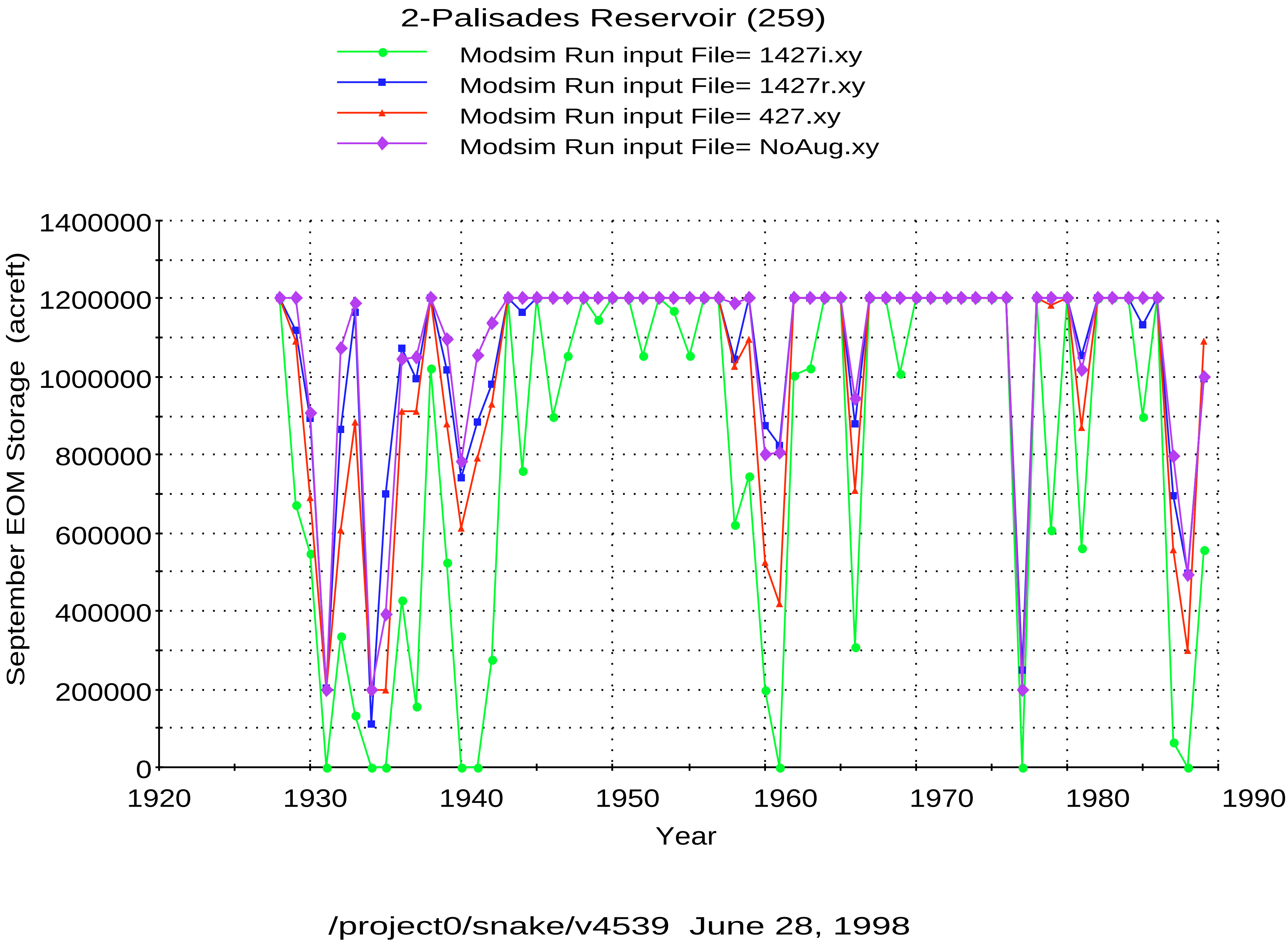
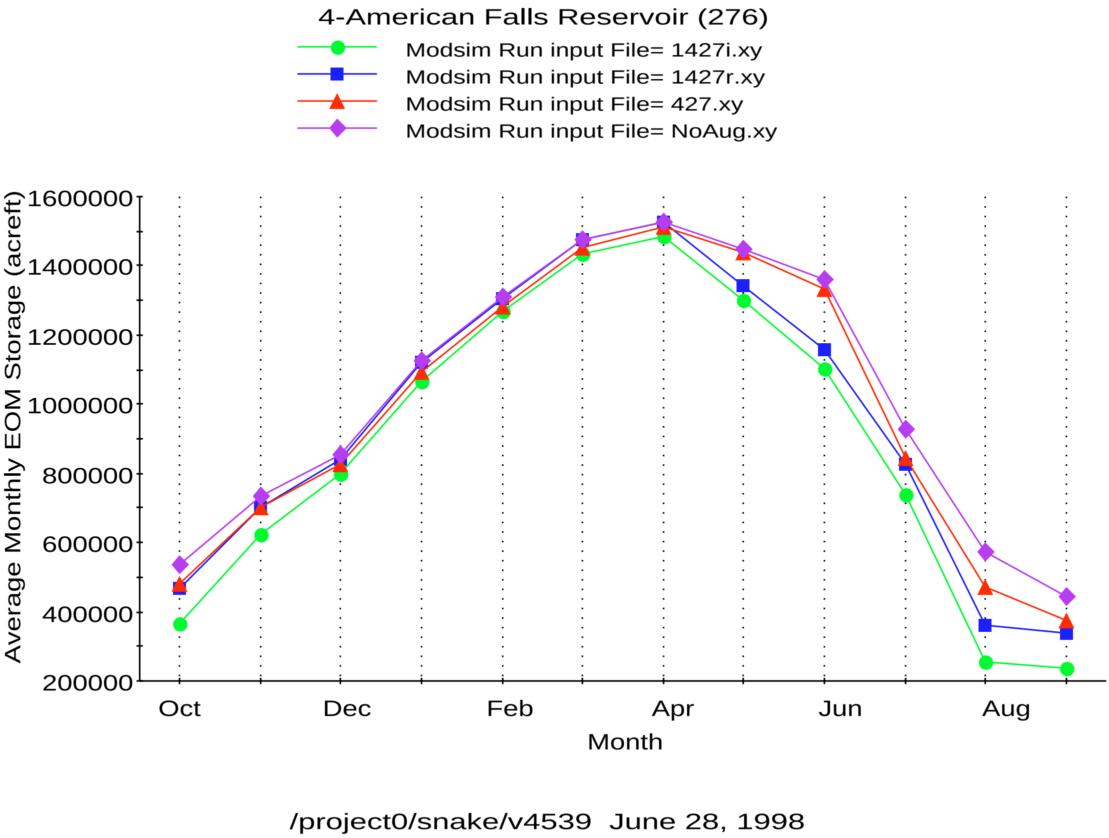


Figure 5-9 Palisades Reservoir End of Season Content (1928-1989)



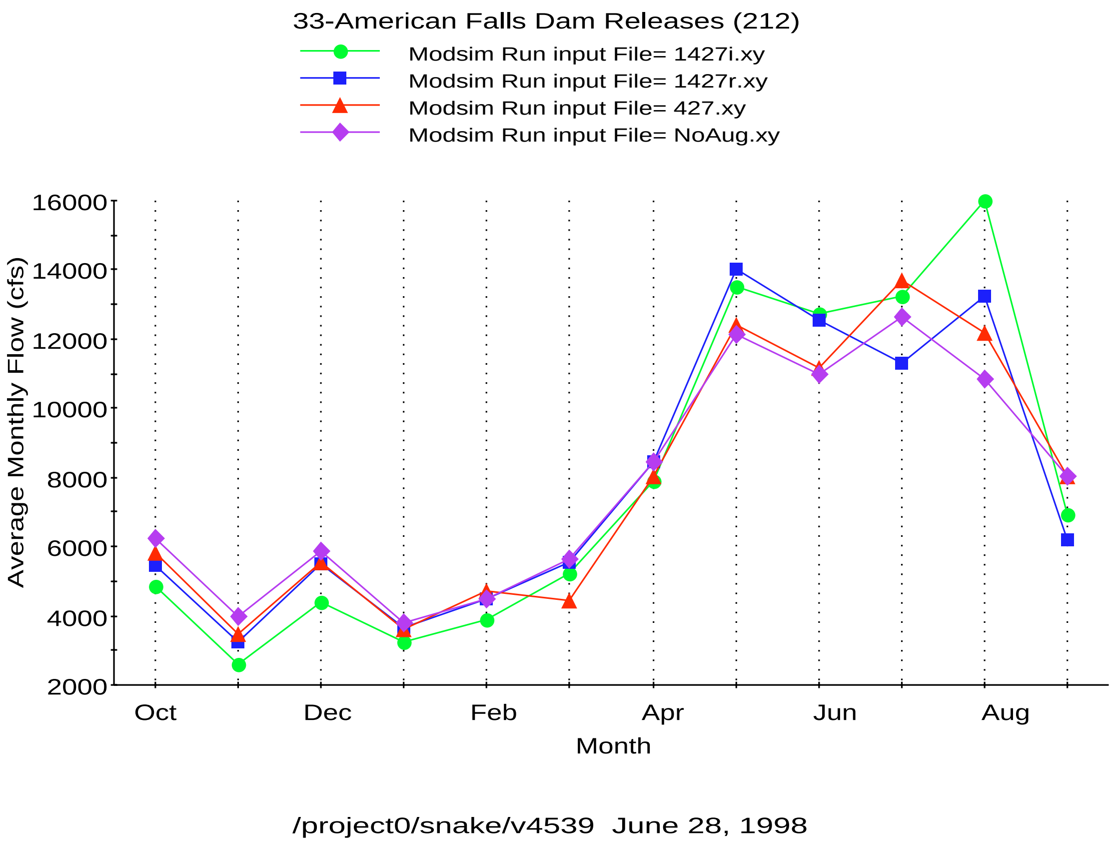


Figure 5-10 American Falls Reservoir Average End of Month Content and Average Monthly Release

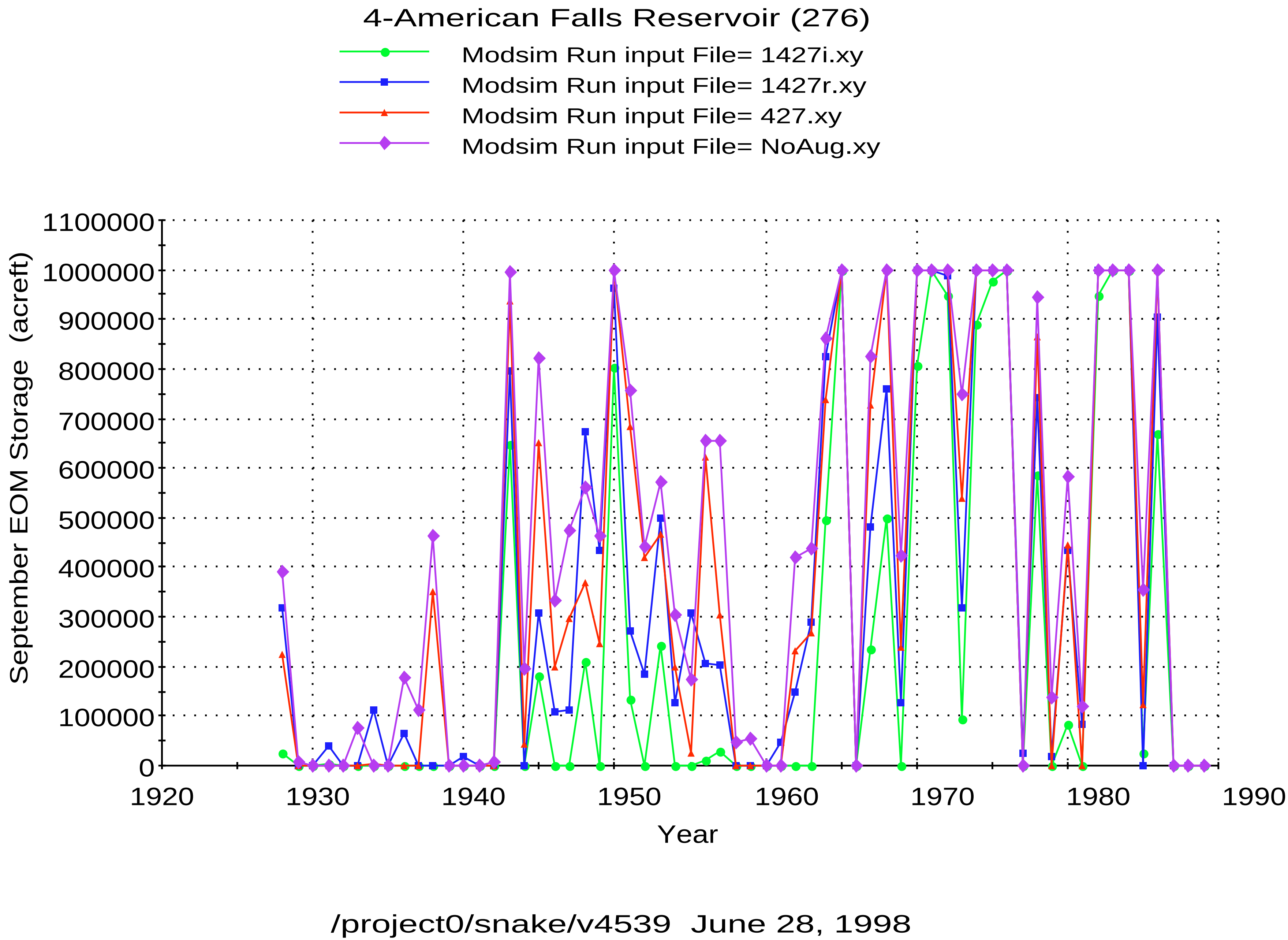


Figure 5-11 American Falls Reservoir End of Season Content (1928-1989)

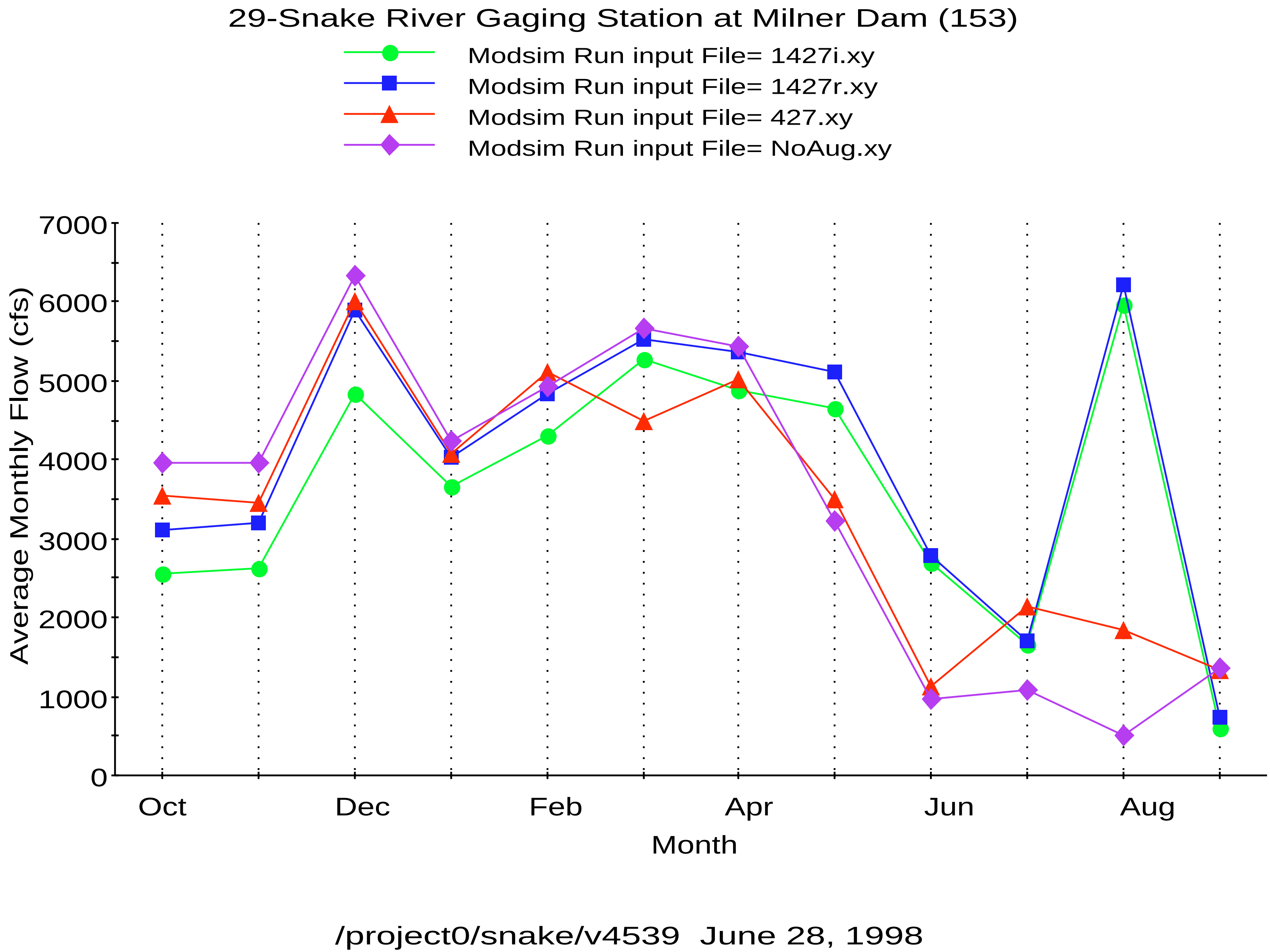
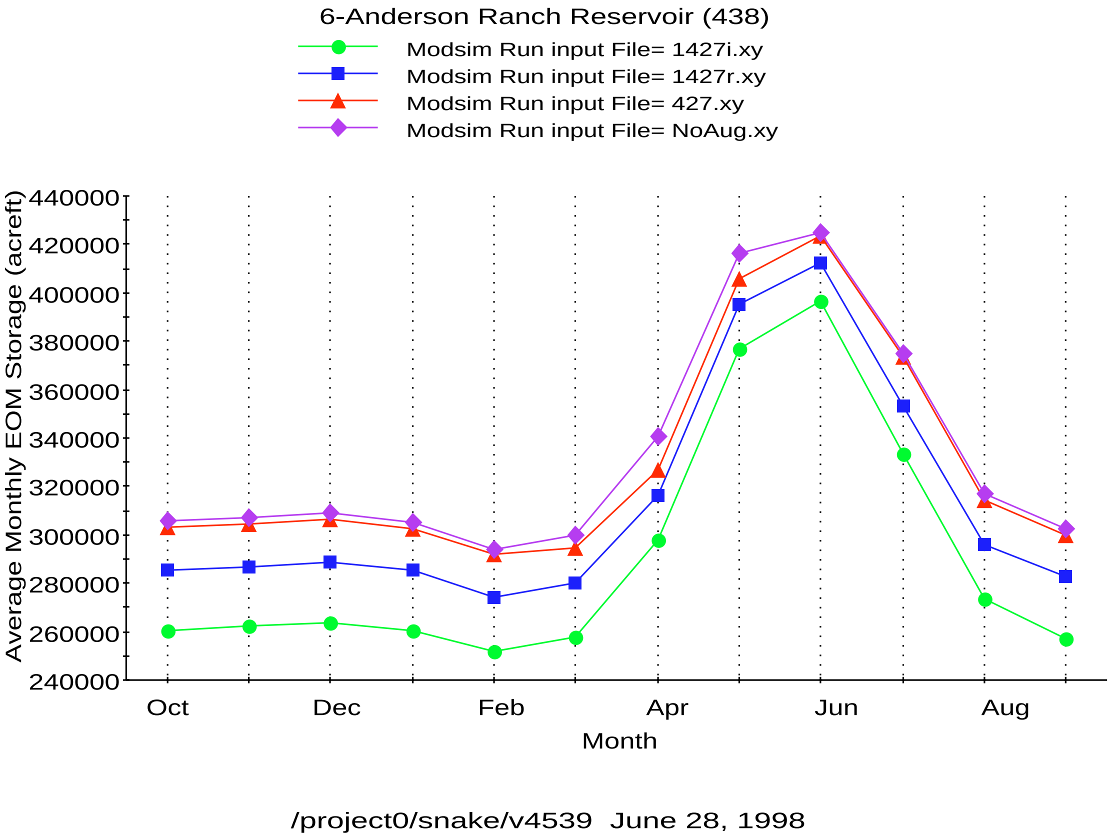


Figure 5-12 Milner Dam Average Monthly Release (Snake River Downstream of Milner Dam)



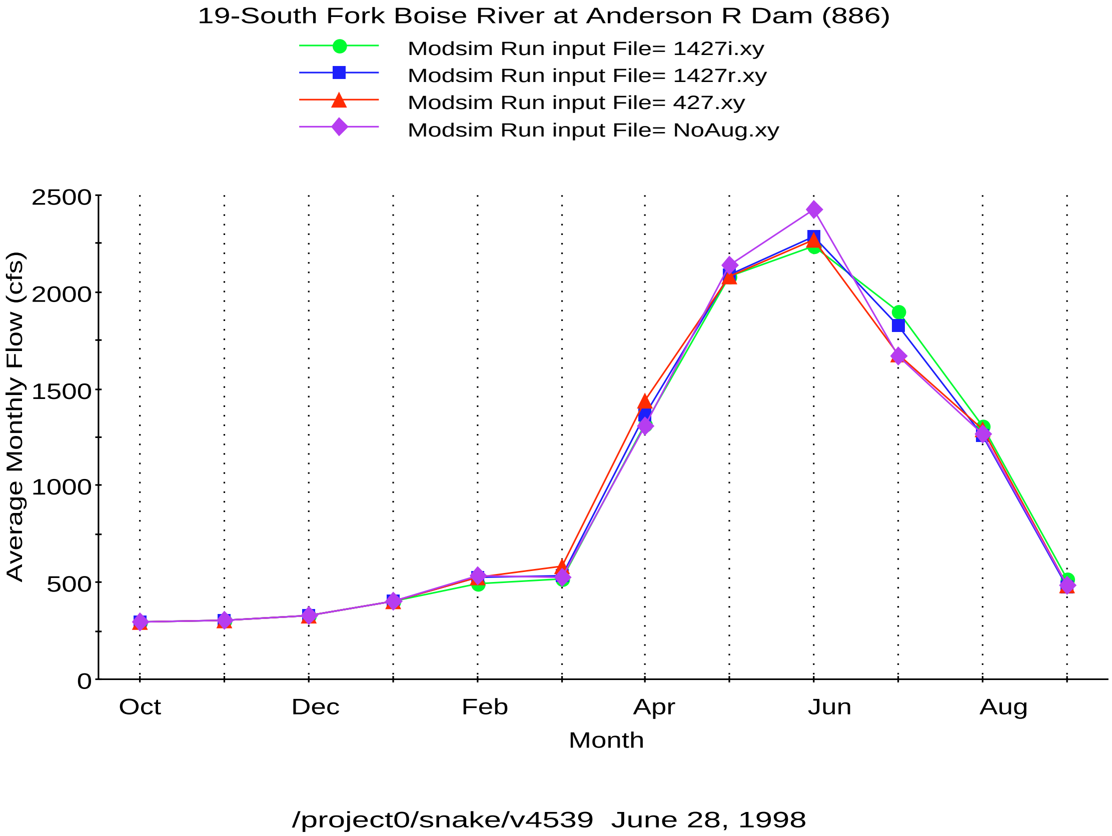


Figure 5-13 Anderson Ranch Reservoir Average End of Month Content and Average Monthly Release

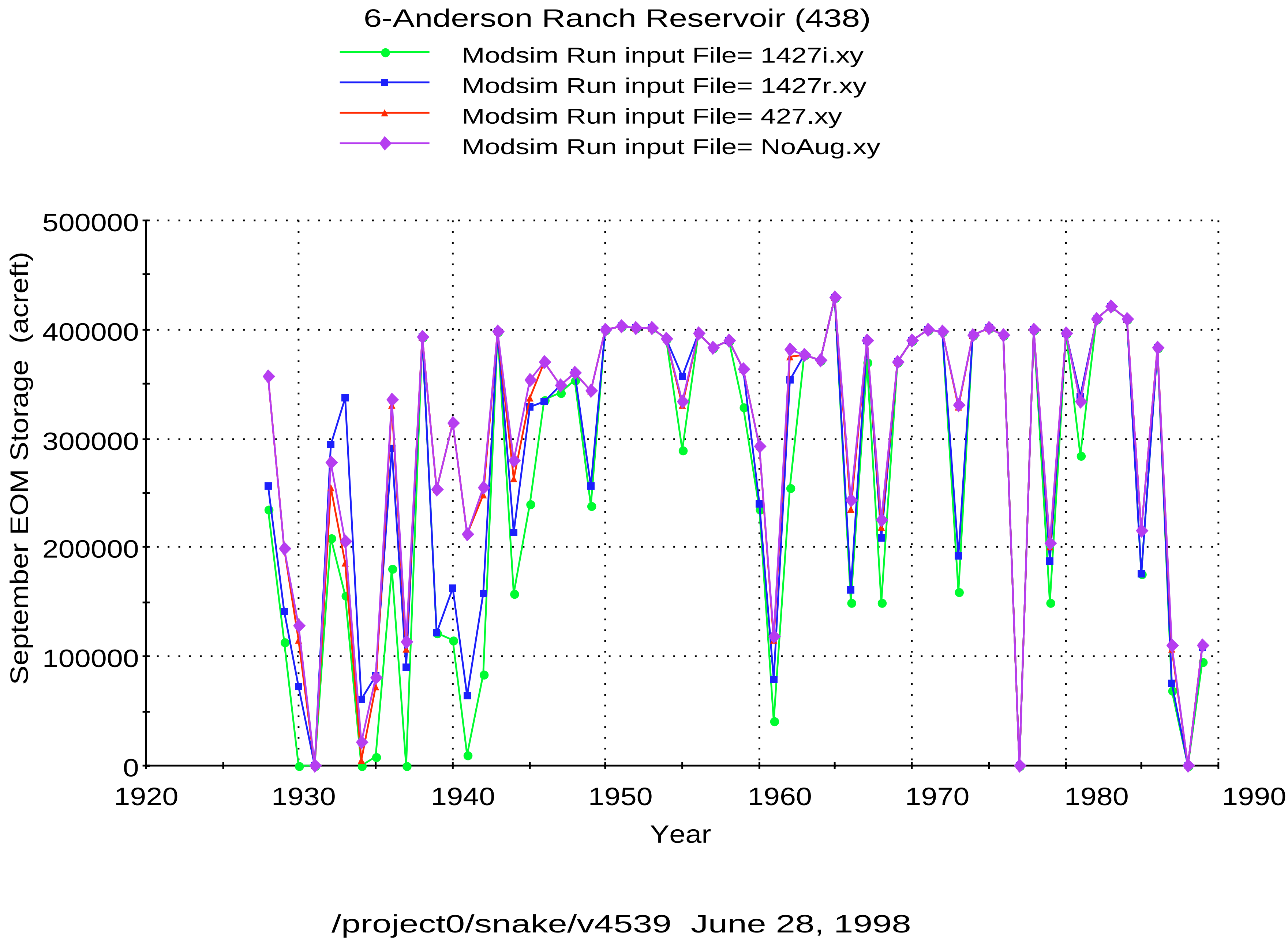


Figure 5-14 Anderson Ranch Reservoir End of Season Content (1928-1989)

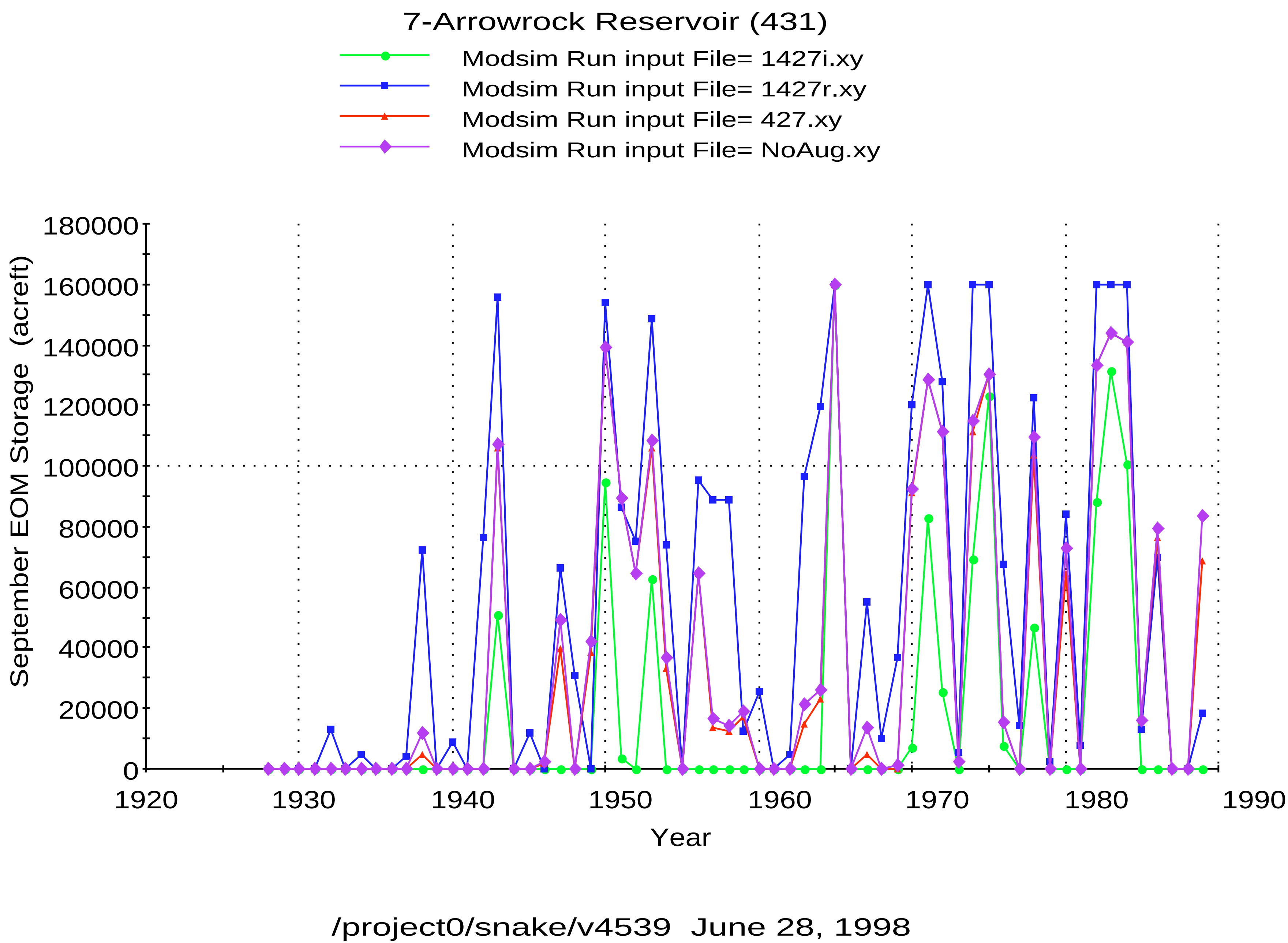
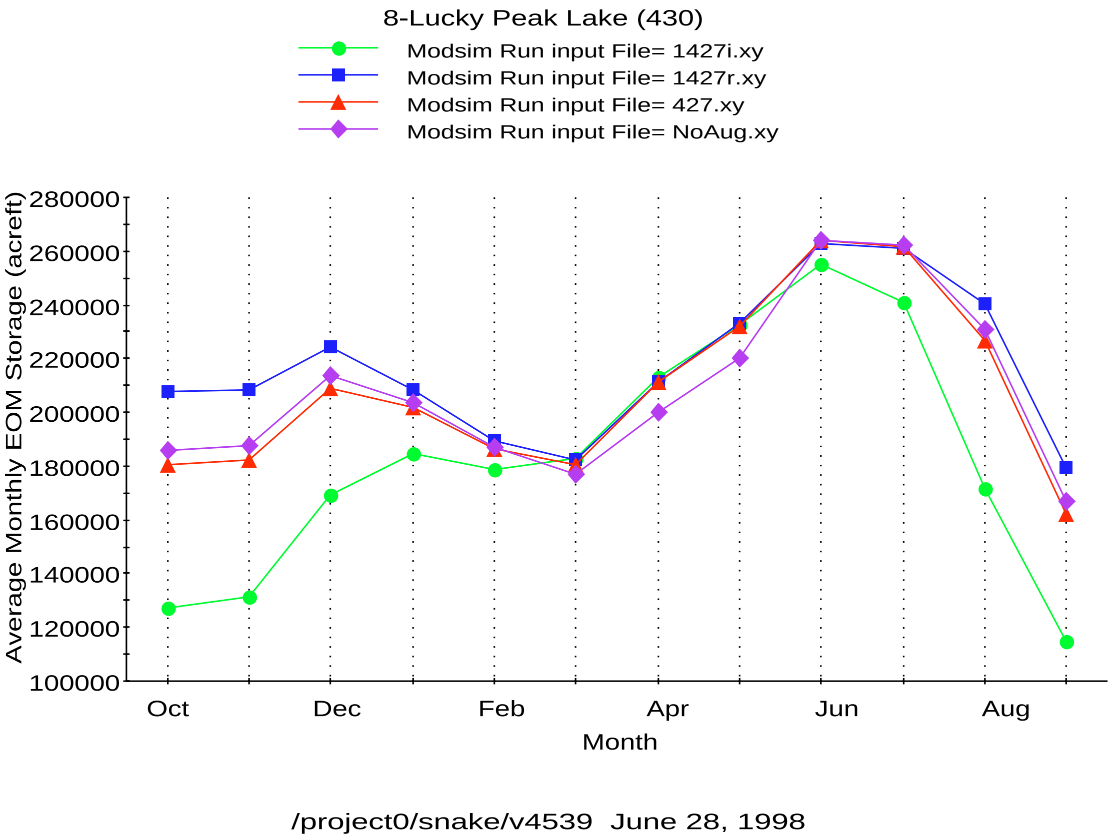


Figure 5-15 Arrowrock Reservoir End of Season Content (1928-1989)



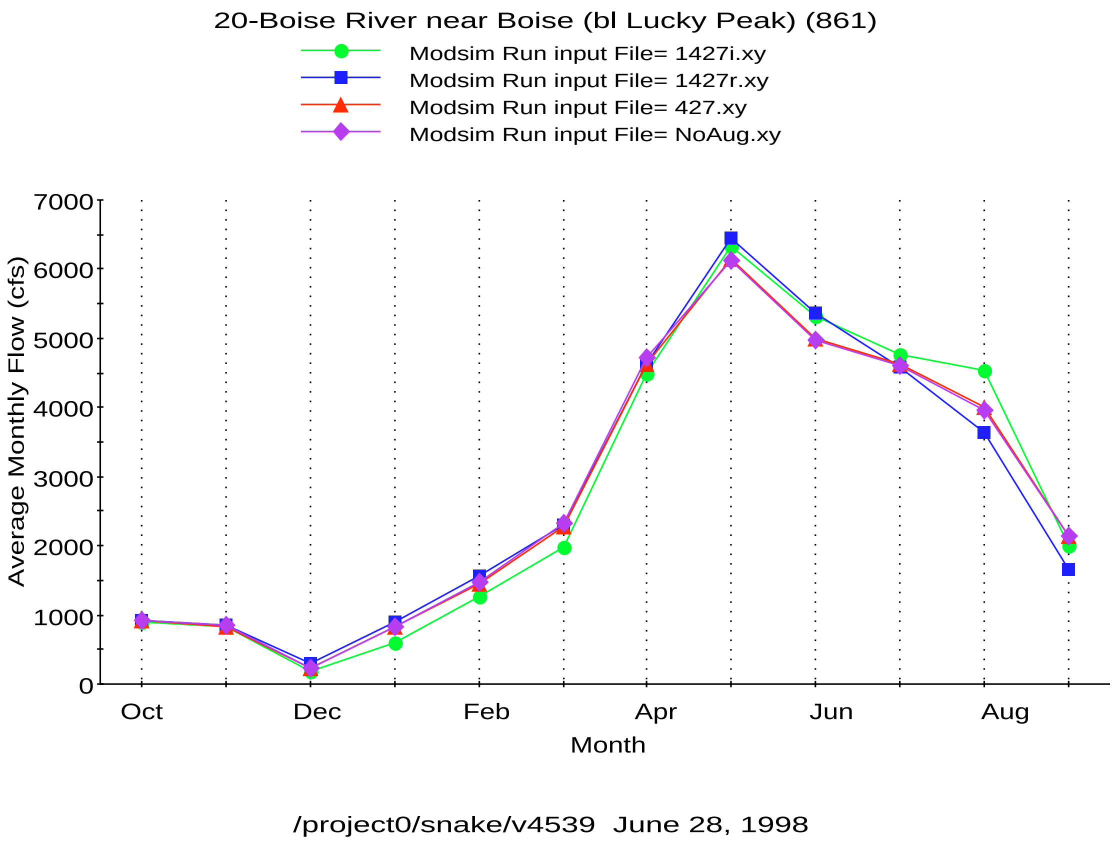


Figure 5-16 Lucky Peak Lake Average End of Month Content and Average Monthly Release

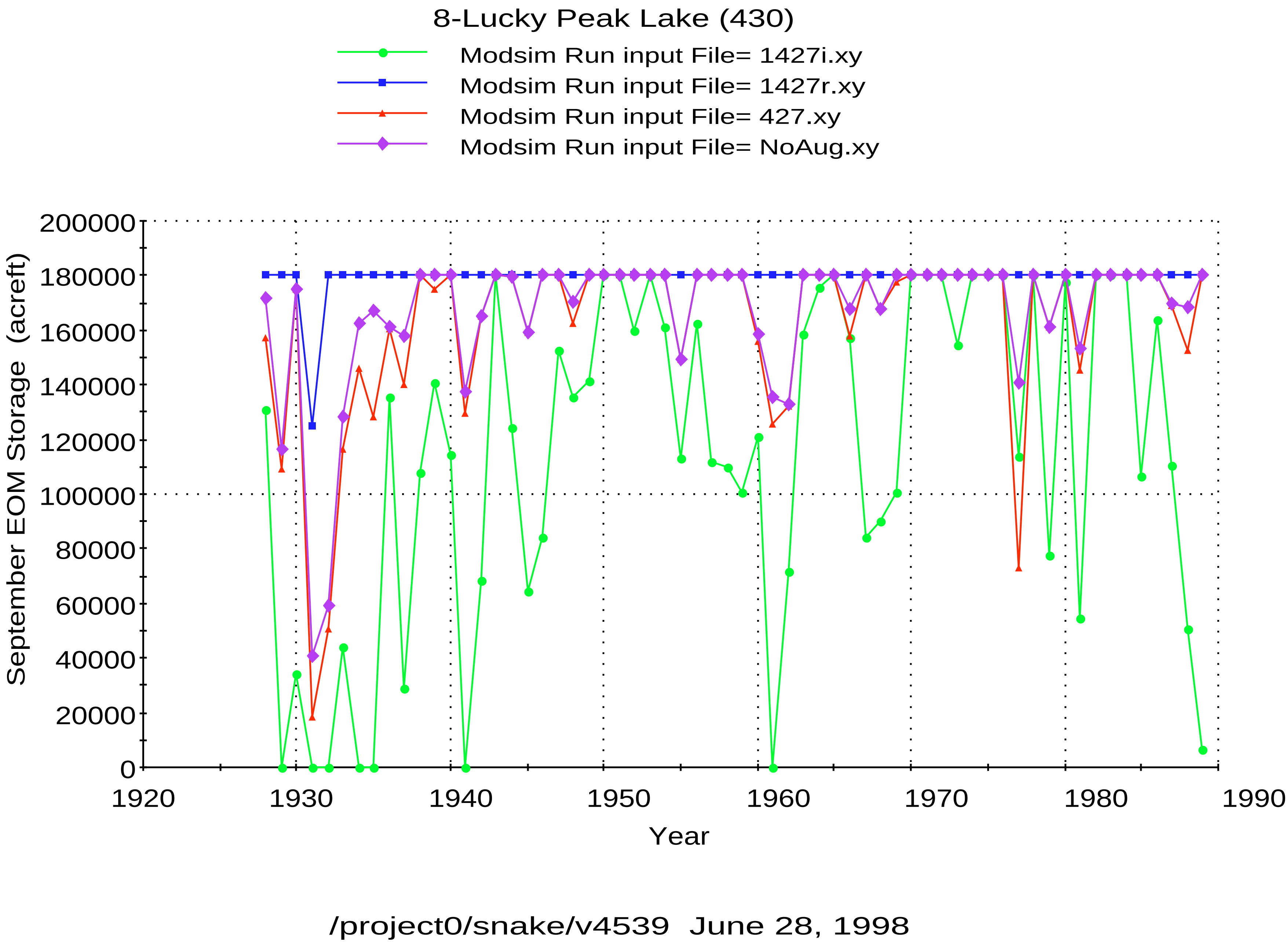
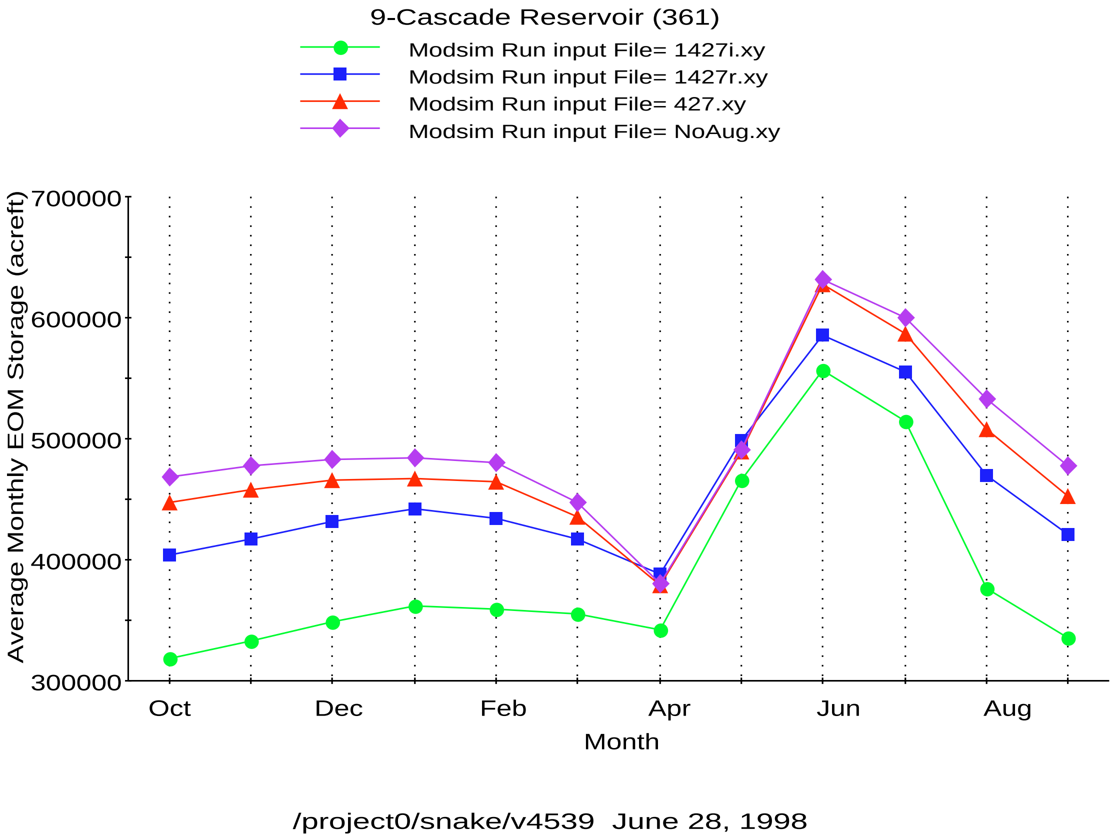


Figure 5-17 Lucky Peak Lake End of Season Content (1928-1989)



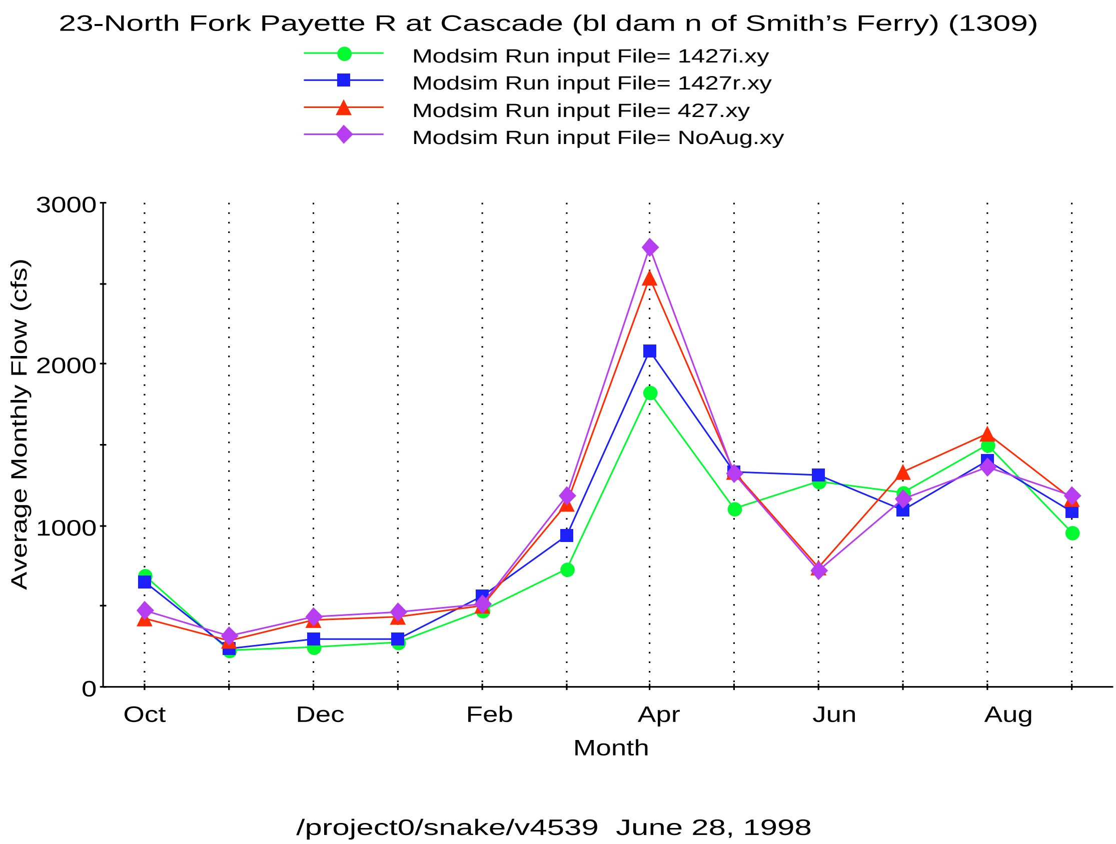


Figure 5-18 Cascade Reservoir Average End of Month Content and Average Monthly Release

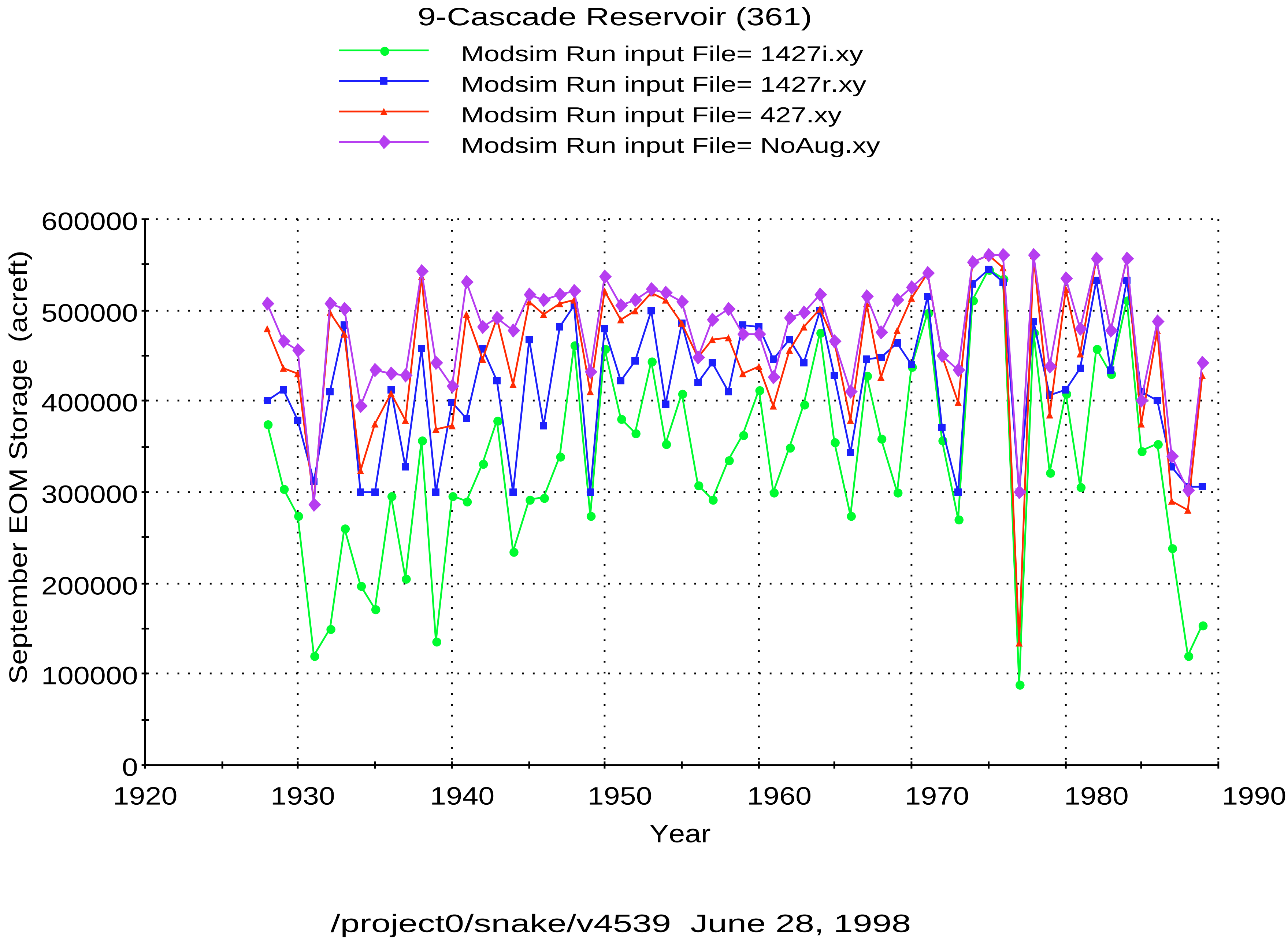
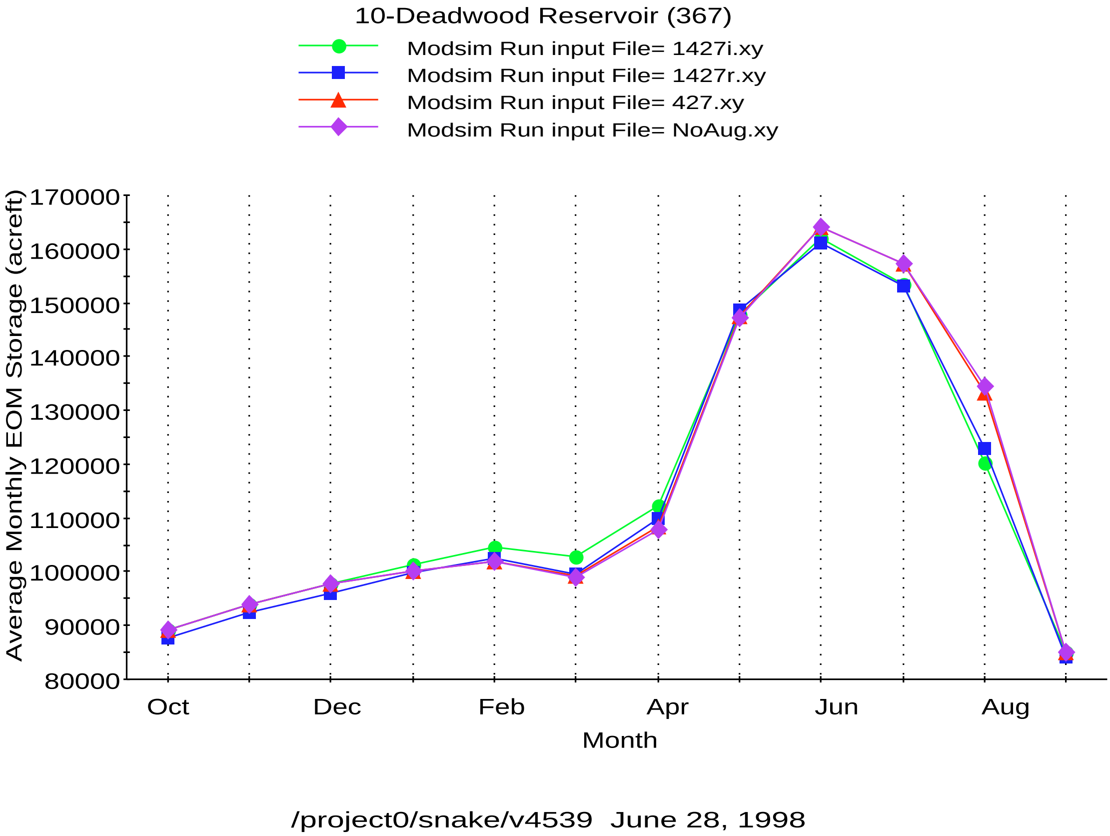


Figure 5-19 Cascade Reservoir End of Season Content (1928-1989)



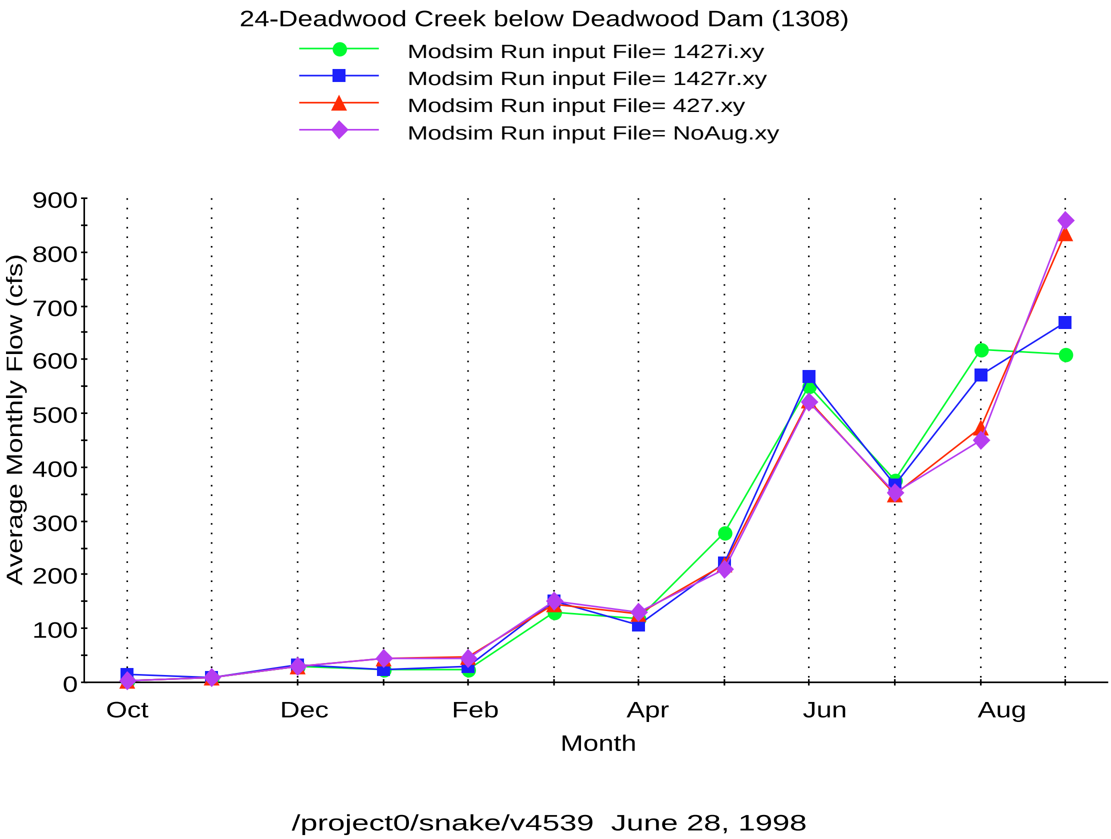


Figure 5-20 Deadwood Reservoir End of Season Content (1928-1989)

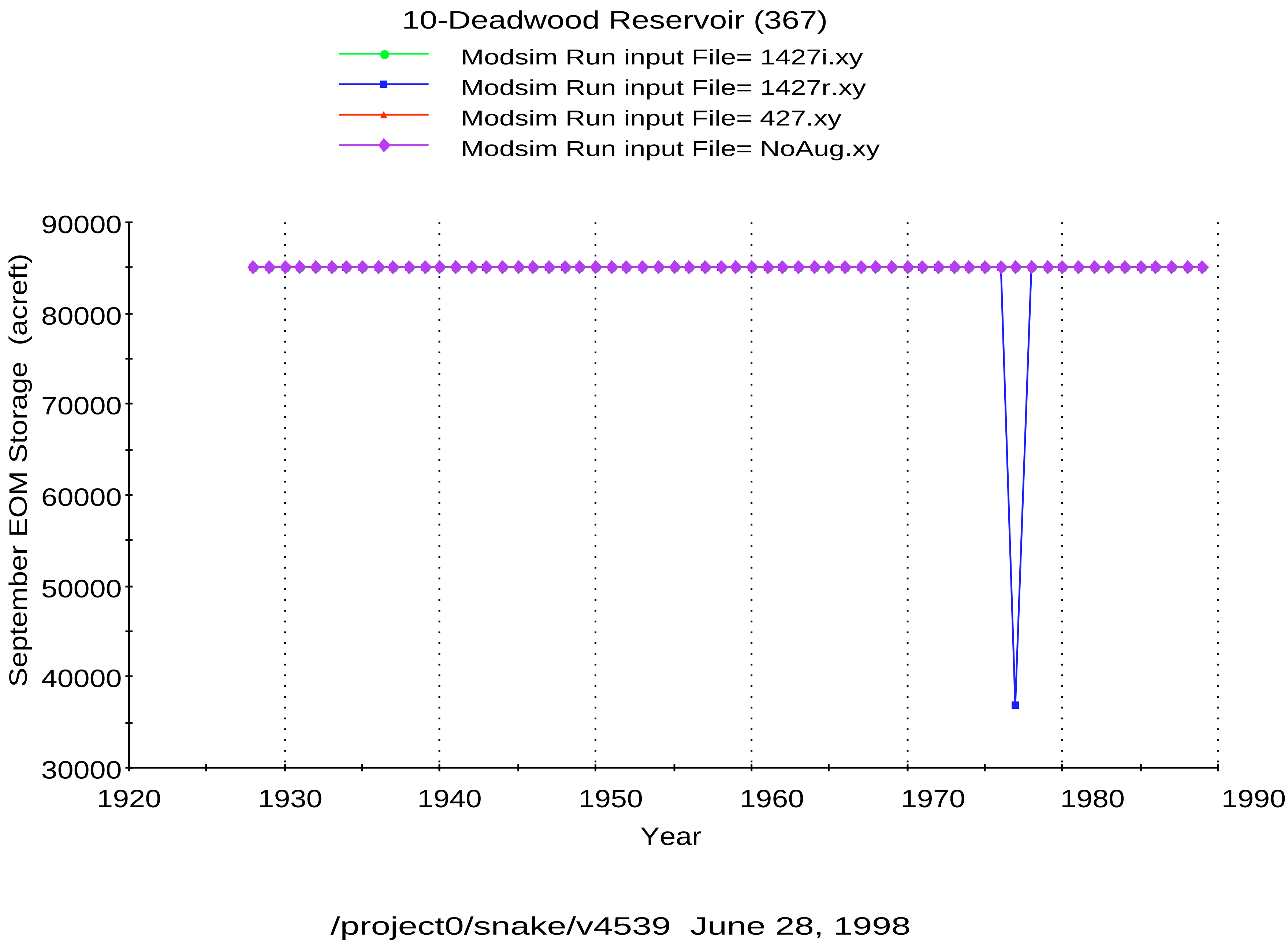
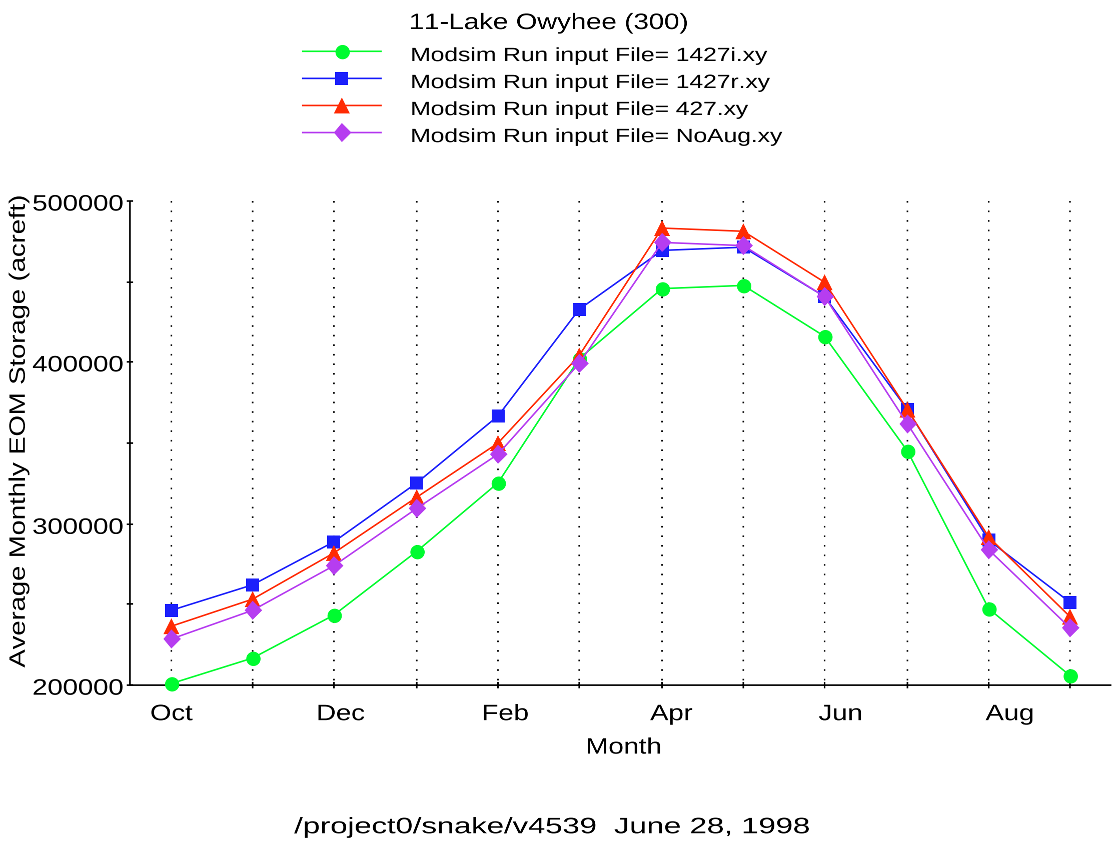


Figure 5-21 Deadwood Reservoir Average End of Month Content and Average Monthly Release



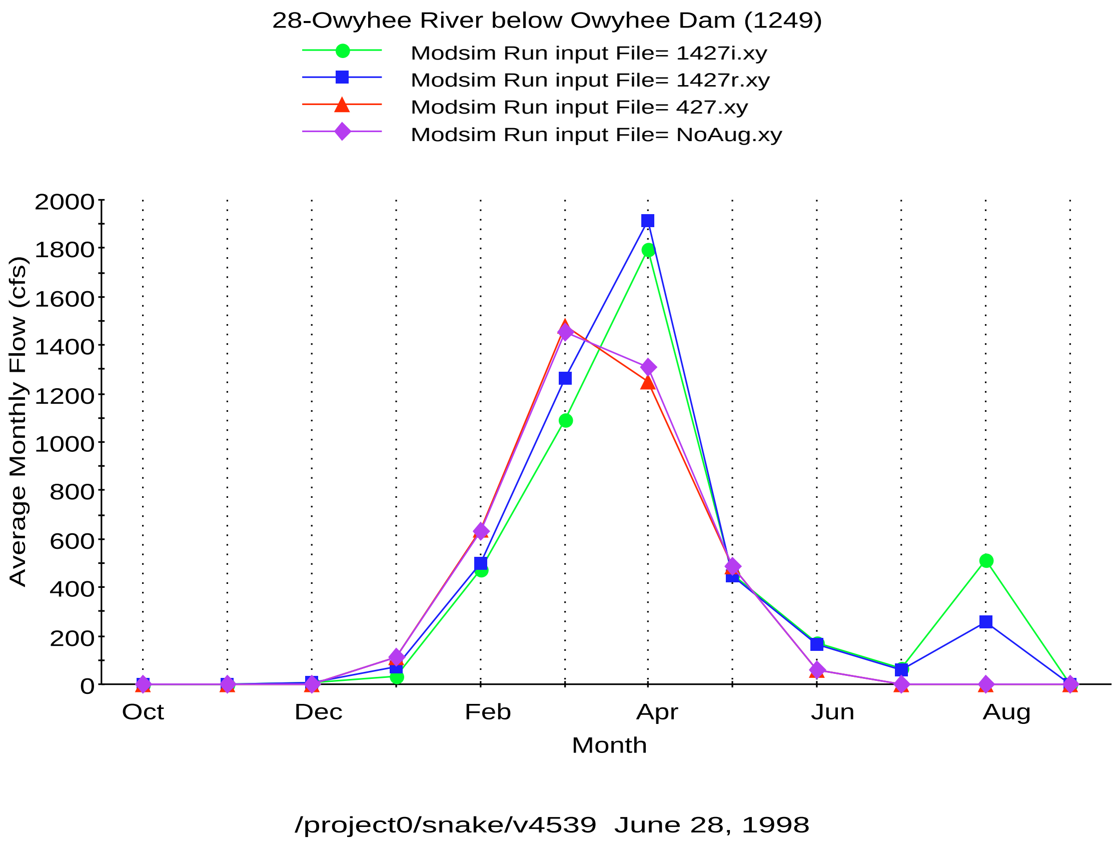


Figure 5-22 Lake Owyhee Average End of Month Content and Average Monthly Release (Owyhee River)

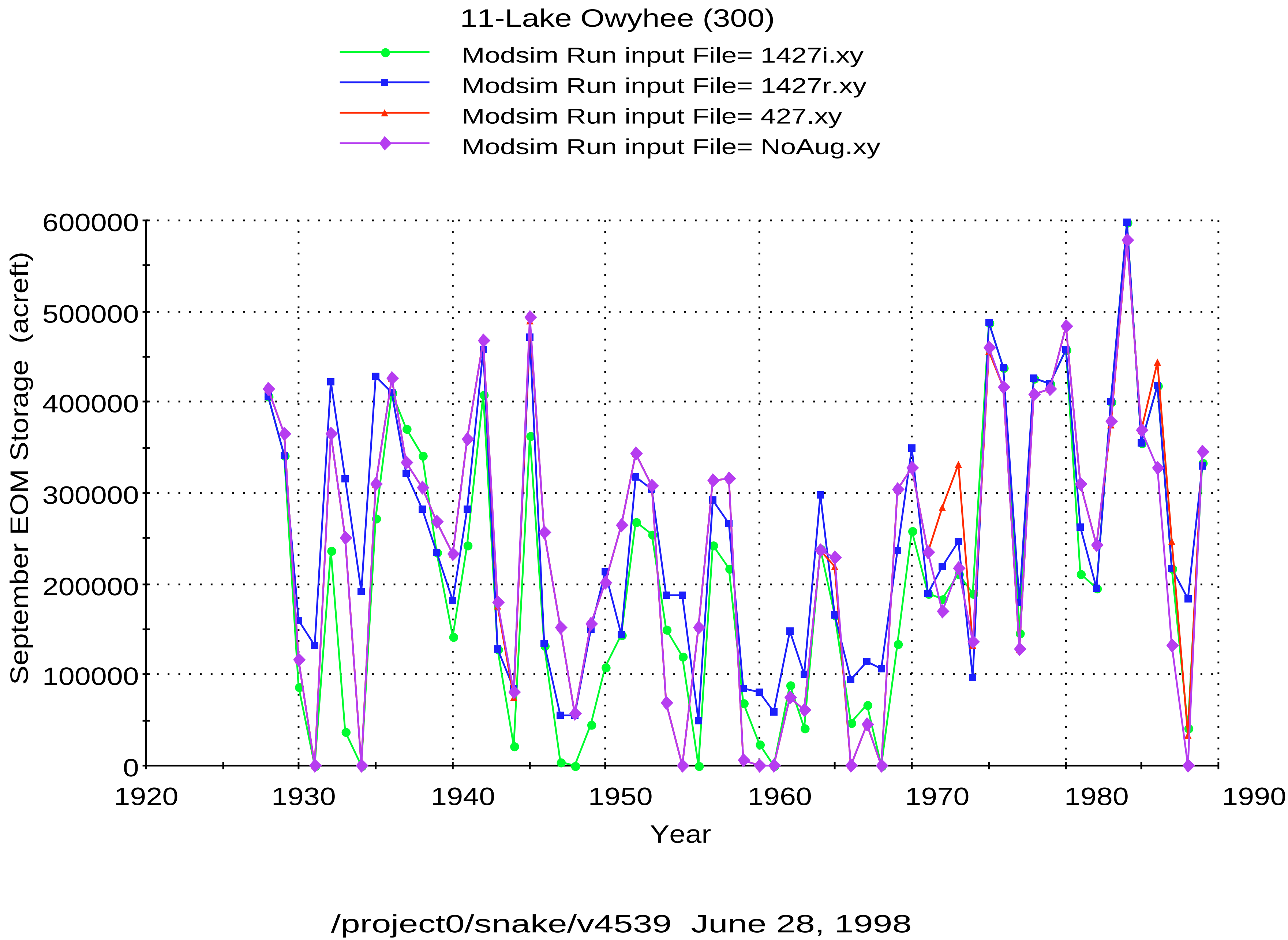


Figure 5-23 Lake Owyhee End of Season Content (1928-1989)

5.2.4.2 Boise River Basin

Table 5-11 Percent of Time Selected Operating Considerations Are Met in the Boise River Basin

Reservoir and Consideration	Base Case	No Augmentation	1427i	1427r
Anderson Ranch release				
600 cfs minimum (April-September)	77	77	77	76
300 cfs minimum (September-March)	78	77	77	77
Lucky Peak Lake release				
80 cfs minimum (November-February	80	80	72	85
150 cfs minimum (October-March)	78	81	71	85
240 cfs minimum (July-March)	81	81	76	84
1,500 cfs maximum at Glenwood Bridge (May-Sep)	75	75	50	48

5.2.4.3 Payette River Basin

Table 5-12 Percent of Time Selected Operating Considerations are Met in the Payette River Basin

Reservoir and Consideration	Base Case	No Augmentation	1427i	1427r
Cascade				
300,000 acre-foot minimum pool (all months)	95	95	70	100
Cascade release				
200 cfs minimum (all months)	100	100	100	95
Deadwood				
50,000 acre-foot minimum (all months)	100	100	100	99
Deadwood release				
50 cfs minimum (all months)	51	52	49	51

5.2.4.4 Owyhee River Basin

Table 5-13 Percent of Time Selected Operating Considerations Are Met in the Owyhee River Basin

Reservoir and Consideration	Base Case	No Augmentation	1427i	1427r
Lake Owyhee release				
10 cfs minimum (October-March)	15	15	10	10
100 cfs minimum (April-September)	14	14	31	28

5.3 Groundwater Modeling and Analysis

Preliminary MODSIM simulations of the 1427r scenario identified irrigation water shortages necessary to provide streamflow to meet the target flow augmentation goal. These shortages would require fallowing about 130,000 acres of lands currently surface-water irrigated in the eastern Snake River Plain. The locations of canal service areas associated with the shortages (fallowed lands) were chosen in the MODSIM simulations to be (1) the Twin Falls North Side and Milner Gooding Canals, (2) the Twin Falls South Side Canal, and (3) the Minidoka Irrigation District.

Elimination of irrigation diversions of about 490,000 acre-feet per year to the three areas was assumed to reduce aquifer recharge by about 205,000 acre-feet per year. For this analysis, it was assumed that of the eliminated diversions, 45 percent would have been consumptively used, 13 percent would have returned to the river as surface flows, and 42 percent would have percolated to recharge the aquifer. Shortages simulated with MODSIM and calculated reductions to recharge in the eastern SRPA for each of the three areas described above are listed in table 5-14.

Table 5-14 Modeled Irrigation Diversion Shortages and Groundwater Recharge Reductions

Zone	Canal Service Area	Irrigation Shortage (Acre-Feet per Month)	Recharge Reduction (Acre-Feet per Month)
1	Twin Falls and Northside/Milner-Gooding	39,411	16,553
2	Twin Falls Southside	951	399
3	Minidoka Irrigation District	446	187
	Total	40,800	17,100

The effect of reduced recharge in these areas on groundwater discharge to springs and groundwater levels was evaluated using unit response functions (Maddock and Lacher, 1992) in conjunction with a groundwater flow model of the eastern SRPA (Garabedian, 1992). Response functions were generated by applying a unit stress that represents reduced recharge to a single 16 square-mile cell in the groundwater model located within each of the three service areas. The response from the unit stress applied to each cell was manifested as a reduction in groundwater discharge to each cell that represented the Snake River between Blackfoot and King Hill in the groundwater model. These responses were normalized from a response to a unit stress from each of the canal service areas to the full amount of recharge reduction from all three service areas, aggregated for each of seven individual reaches, and converted into a percent of response for each reach in a separate computer program. Reaches and percent responses to the recharge reductions are shown in table 5-15.

Table 5-15 Response to Reduced Groundwater Recharge (Percent)

River Reach	King Hill-Hagerman	Hagerman-Buhl	Buhl-Kimberly	Kimberly-Milner	Milner-Minidoka	Minidoka-Neeley	Neeley-Blackfoot
Percent response	5	15	41	10	15	7	7

Although reductions in groundwater discharge would be expected to vary somewhat seasonally, reductions were simulated as a constant that was applied to each month of the year to simplify the analysis. Reductions in groundwater discharge for each reach were represented in the final MODSIM simulation of the 1427r scenario by setting a demand of 17,000 acre-feet per month multiplied by the percentages listed in table 5-15.

Groundwater level declines in the eastern SRPA associated with the reduction in recharge described above were evaluated with response functions in a fashion similar to that described above for groundwater discharge to the Snake River. Declines were estimated at model cells that were 8-10 miles down the hydraulic gradient from the point where the reduction in recharge was applied. Water level declines after 50 years of simulation are summarized in the table 5-16.

Table 5-16 Project Water Groundwater Decline After 50 Years

Canal Service Area	Groundwater Decline (Feet)
Twin Falls North Side/Milner Gooding	46
Twin Falls South Side	44
Minidoka Irrigation District	28

The presence or absence of irrigation by highlift pumping from the Snake River between Twin Falls and Murphy was assumed to have no significant effect on groundwater. Those operations were assumed to deliver an amount of water close to crop consumptive use requirements. Thus, a reduction of irrigation in this area would have no effect on groundwater.

Changes in irrigation in the Salmon, Grande Ronde, and Owyhee River basins and in Wyoming upstream from Palisades Reservoir would not significantly affect the overall basin water budget. Reduced irrigation in these areas would reduce groundwater recharge and affect groundwater storage and dynamics locally. Although these impacts could be locally significant and could warrant further investigation, groundwater yield in these areas are minor relative to the overall basin water budget and was not modeled for this analysis.

Reallocation of reservoir storage in the Boise and Payette River systems was considered to affect groundwater conditions and groundwater and surface water relations in these river basins. As described for the eastern Snake River Plain, storage reallocation would result in less water diverted to irrigate crops. Hence, less groundwater recharge and less groundwater discharge to streams were assumed to occur. Irrigation shortages that would result from reallocation of reservoir storage to meet target surface water yields from the Boise and Payette River basins were identified in preliminary MODSIM runs. Recharge to the underlying aquifer in these basins was assumed to be 50 percent of the irrigation shortages. All of this recharge was assumed to return to the rivers as groundwater discharge. The returns were lagged over 3 months with 4/7ths returning in the same month that the shortage was simulated, 2/7ths in the next month, and 1/7th in the last month. The returns obtained by this method were applied to the MODSIM model as an incremental demand or river loss at specified locations where local gains were represented in the Base Case.

Groundwater recharge from irrigation has historically resulted in a significant rise in groundwater levels in the Boise River basin and likely contributes to high groundwater levels in the Payette River basin. Under the 1427r scenario reduced recharge likely would lead to groundwater level declines in these basins. However, magnitude of anticipated declines was not quantified.